Gold, arsenic and antimony in stream sediment related to supracrustal units between Arfersiorfik and Qarajaq Isfjord (68°N to 70°30′N), West Greenland

Agnete Steenfelt

Open File Series 92/4

April 1992

GRØNLANDS GEOLOGISKE UNDERSØGELSE
Kalaallit Nunaanni Ujarassiortut Misissuisoqarfiat
GEOLOGICAL SURVEY OF GREENLAND

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ISSN 0903-7322

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Introduction

This report presents data from the Geological Survey of Greenland's geochemical mapping programme based on drainage samples together with preliminary analyses of surface samples (soil and rock) collected at mineralised localities. The aim is to draw attention to the gold potential of supracrustal sequences in the area between Arfersiorfik and Qarajaq Fjord.

The data are compiled from sampling in 1986 (69°N to 70°30'N, Steenfelt 1987, 1988), together with previously unpublished results from additional sampling in 1988 (Nuussuaq), 1989 (68°30'N to 69°N) and 1991 (68°N to Qasigiannguit).

Results of gold in stream sediment surveys in other parts of Greenland are given in GGU Open File series 90/2, 90/5, 91/5, 91/8, and 91/9 (cf. inside of back cover).

Geology

The sampled area is covered by a geological map at the scale of 1:500 000 based on geological reconnaissance along the coasts and air photo interpretation of the interior parts (Henderson, 1969; Escher, 1971). Later investigations proved that revisions of the reconnaissance map are needed, particularly in the Ataa district (Kalsbeek, 1989). A new map of the Ataa district at the scale 1:100 000 is under preparation as well as one at the scale of 1:250 000 covering the Precambrian basement from Jakobshavn Isfjord to Qarajaq Isfjord. The map, Fig. 1, illustrates the present geological interpretation of the area.

This section of the Precambrian Laurentian shield is composed of Archaean gneisses with intercalated supracrustal sequences of both Archaean and Proterozoic ages. The area is generally described as "reworked Archaean" (Escher & Watt, 1976), but recent and ongoing investigations indicate that the nature, degree and age of the reworking vary considerably over the area (Kalsbeek et al., 1987; Kalsbeek et al., 1988; Fig. 1). Lithologically, gneisses with tonalitic to granodioritic composition predominate and they are tectonically intercalated with units of supracrustal volcanic and sedimentary rocks. A distinction between Archaean and Proterozoic supracrustals has been made in some instances by isotopic methods (Fig. 1; Kalsbeek et al. 1987; Kalsbeek, pers. comm. 1992), but the ages of most of the southern occurrences are not known. In the southeastern corner of the area described dioritic intrusions (and some occurrences of supracrustal rocks) have been shown to be of Proterozoic age (Kalsbeek et al. 1987).

Further information on the supracrustal units is given in the discussion of the distribution of gold (Au), arsenic (As), and antimony (Sb).

Sampling and analysis

The samples are collected from evenly spaced sites with a density of 1 site per 30 km^2 using the same sampling technique:

At each station c. 500 g of stream sediment, composed of 5 to 10 subsamples from different sites of sand and silt deposits in the bed or banks, were collected in a paper bag. Further, 100 ml of stream water was collected in a polyethylene bottle and the radioactivity (total gamma-radiation) was measured on the surface of outcrops or stream boulders using a scintillometer. Duplicate samples of both stream sediment and water were collected at c. 5 % of the sites.

The stream sediment samples were dried and sieved and the <0.1 mm grain size fraction analysed by instrumental neutron activation method for 34 major and trace elements including Au, As and Sb. Samples collected 1986-1989 were analysed at Bondar-Clegg & Company Ltd. and samples from 1991 were analysed at Activation Laboratories Ltd., both in Canada. Standard samples analysed both places showed no laboratory bias for Au, As and Sb.

Distribution patterns of Au, As and Sb and mineralisation

The contents of these three elements in the stream sediment is commonly below the analytical detection limit of 5 ppb for Au, 2 ppm for As, and 0.2 ppm for Sb. Thus it is not possible to determine the true geochemical background. Based on stream sediment data from all over the Precambrian basement of Greenland the geochemical background for Au is estimated at about 5 ppb, hence values above that are taken to represent raised background or anomalies. Because of the uncertainty involved in analysing for Au at the low ppb level the actual values obtained must be regarded as semiquantitative. However, the distribution pattern of the gold bearing samples is regarded highly significant and clusters of samples with elevated Au content are usually indicative of mineralisation.

Values for Au above 5 ppb (Fig. 2) occur throughout the area and form clusters which can be related to enclaves of supracrustal rocks, compare Fig. 1. The distributions of As (Fig. 3), on the contrary, display clusters of high values in the north, a very low level in the central part and a slightly elevated level in the southern part with a single linear cluster of higher values at the southern edge of the area. The Sb distribution (Fig. 4) resembles

that of As except for a few high values in the central part. In the following the differences in the distribution patterns for Au, As and Sb are discussed in relation to lithology and known mineralisation for each of the districts outlined in Fig. 5.

Saqqaq-Torsukattak district

Two large supracrustal units of assumed Archaean age are tectonically interleaved with gneisses in an Archaean terrane which has undergone strong Proterozoic deformation. The sequence of mafic and ultramafic metavolcanic rocks, pelitic and chemical metasediments is metamorphosed to amphibolite facies and deformed in at least 2 phases of folding. In a recent investigation of the Saqqaq unit (Thomassen and Tukiainen, 1992) a rusty horizon has been identified as sulphide mineralised metachert, and 5 chip samples across 3-4 m of the horizon along 1.6 km strike length yielded 0.4 to 1.8 ppm Au. The mineralisation is believed to be syngenetic exhalative associated with sulphide facies iron formation. The enrichment of As and Sb in the mineralisation (and reflected by the stream sediment) is viewed as a result of the exhalative activity. The stream sediment response in Au is weak (5 to 10 ppb), but nevertheless significant as indicator of the gold mineralisation.

The Au, As, and Sb values relating to the supracrustal rocks at Torsukattak compare well with those of the Saqqaq unit and in view of a similar geological setting this unit is also believed to be favourable for gold mineralisation of syngenetic exhalative type.

The supracrustals at Torsukattak were explored geophysically and geologically in the late 1970'es and early 1980'es by Kryolitselskabet Øresund A/S for base metal sulphides (Gothenborg, 1985). Drill core sections from a Cu-prospect at Itilli (previously spelled Itivdle; Fig. 5) were later analysed for Au and Ag together with a number of Cu-sulphide mineralised rock samples. The result showed that 29 out of 71 analysed samples had Au above 130 ppb (median 440 ppb Au, maximum 5 ppm Au, and median 10 ppm Ag); a sample of a quartz vein gave 2.5 ppm Au and 13.5 ppm Ag (Sotka, 1984a; Gothenborg, 1985). The As concentration is occasionally very high (up to 19% in one rock sample). 12 soil samples collected by the present author near the prospect yielded up to 140 ppb Au, 19 ppm As, and 0.5 ppm Sb.

The analyses from Itilli indicate that Au is associated with Cu. The Cu-mineralisation at the drill site is epigenetic (fracture filling) in character. However, in the light of the discovery of syngenetic mineralisation in the

Saqqaq unit (Thomassen & Tukiainen, 1992) and the strong stream sediment response in As and Sb at Itilli, the latter prospect may be regarded as a remobilised "Saqqaq type" syngenetic mineralisation.

Ataa district

This small district of granite-greenstone terrain comprises supracrustal units of mafic and subordinate felsic metavolcanics which were intruded by the Archaean Atâ tonalite. Proterozoic metasediments unconformably overlying the Archaean supracrustal units are folded but metamorphism is weak and the isotope systems in the tonalite are undisturbed (Kalsbeek et al. 1988). The region has escaped severe Proterozoic reworking. Samples with anomalous As are restricted to the Archaean units whereas Sb and Au values occur both in Archaean and Proterozoic units.

The exploration for base metal sulphides by Kryolitselskabet Øresund A/S also comprised the supracrustals at Anap Nunaa (Fig. 5) of the Ataa district. Gold mineralisation was found in the Archaean units, principally at Eqe (Fig. 5; Sotka, 1984a,b; Gothenborg, 1985). Later investigations were carried out by GGU (Knudsen et al., 1988) and by a joint venture of Platinova Resources Ltd. and Faxe Kalk (Knudsen et al., 1990). Epigenetic gold occurs in a breccia (up to 12 ppm Au) and in carbonatised volcanic rocks (up to 8 ppm in chip samples and up to 60 ppm Au in a single sample from a small quartz vein). The geochemical association of Au with both As (10 to 45 ppm in stream sediment, 3010 ppm in a soil sample) and Sb at Eqe (Fig. 2 to 4) in combination with the occurrence of horizons of banded iron formation in the supracrustal sequence suggests that the environment was similar to that of the Saqqaq unit and, therefore, that syngenetic Au mineralisation may also have formed at Eqe.

The fairly large greenstone occurrence west of Ataa also gives rise to elevated contents of Au, As, and to a less degree Sb, in the stream sediment samples. Metasedimentary units intercalated with metavolcanics host small occurrences of massive sulphides (pyrite, pyrrhotite, chalcopyrite, sphalerite). Three sulphide mineralised samples reported in Knudsen et al. (1988) showed up to 620 ppb Au, 3060 ppm As, and 3 ppm Sb. The massive sulphides may be interpreted as syngenetic sulphide facies iron formation (M. Marker and H.K. Schønwandt, pers. comm. 1991).

There are two anomalous Au values (25 and 29 ppb) in the Proterozoic supracrustals and several high Sb values. Small occurrences of sulphide mineralised breccias in Proterozoic marble sampled by Kryolitselskabet Øresund

A/S were reported to contain up to 2 ppm Au, 115 ppm Ag, 0.44% Cu, 92 ppm Bi, and 0.22% Sb (Gothenborg, 1985). This minor type of mineralisation which is possibly responsible for the stream sediment anomalies may have been produced by remobilisation of Au and Sb from Archaean units with subsequent emplacement into the Proterozoic strata. Intrusion of ultramafic lamprophyre at Anap Nunaa in Proterozoic times (Thomsen, 1991) may have contributed to the mineralising process by providing heat and/or metals, and penetrative albitisation of large parts of the Proterozoic strata (Kalsbeek, 1992) provides evidence for widespread hydrothermal activity which may also have contributed to the redistribution of Au and Sb.

Ilulissat (Jakobshavn) district

The scattered gold values are not readily attributable to the small mapped occurrences of supracrustal rocks (Fig. 1). The gold bearing samples do not contain As and the two Sb anomalies do not coincide with the gold distribution. A possible locating factor for the Sb and two of the gold values is a prominent NNW-SSE oriented fracture zone (fault?). Otherwise the gold distribution may be explained by remobilised gold hosted by the flat lying south-east dipping shear zones which characterise the gneiss terrain of this district.

Qasigiannguit (Christianshåb) district

In this district the enclaves of supracrustal rocks are fairly large. They are dominated by metasediments including carbonates but also comprise amphibolites. Rusty weathering reflects the common occurrence of sulphides. Graphite is also common. The sedimentary sequence suggests a platform setting and the absence of As and Sb show that the mineralisation indicated by the cluster of gold anomalies is different from those of the Saqqaq-Torsukattak and Ataa districts. The supracrustals are described cursorily by Henderson (1969) but they have not since been investigated or mapped in detail. The stream sediment results indicate that further exploration is warranted.

Naternaq-Arfersiorfik district

Slightly elevated (5 to 20 ppb) and a few higher (20-115 ppb) values for Au are scattered over the southernmost part of the area described. The distribution of As displays a pattern of slightly elevated background rather than distinct clusters except for the anomalies aligned along the Nordre Strømfjord Shear Zone (Fig.1). In the Naternaq-Arfersiorfik district enclaves of supracrustal rocks

make up a considerable proportion of the terrain, and there are many more small enclaves than shown on Fig. 1. Only about half of the elevated Au and As values can be related to known occurrences of supracrustal rocks while the other half appears to be derived from gneiss areas.

In this district Au mineralisation is indicated at three localities. The first is the Lersletten prospect (Fig. 5), discovered and explored for base metals by Kryolitselskabet Øresund A/S (Kurki, 1965; Vaasjoki, 1965). Prominent rust zones are associated with Zn-Cu sulphide mineralisation in supracrustal rocks comprising mica schist, amphibolite and subordinate marble. The supracrustal sequence is intruded by post-tectonic veins of pegmatite and granite. The mineralisation is epigenetic and dominated by pyrrhotite with minor chalcopyrite, sphalerite and graphite.

A few rock samples and 14 soil samples were collected during the drainage sampling programme at the Lersletten prospect (Table 1, sample no. 360807, 360811; Table 2). The analyses indicate mineralisation with Zn, As and Sb, which also contains Au, Mo, and Se. The latter two elements are not present in the other districts covered by this investigation. The samples 360820 and 360821 (Fig. 5) from a sulphide mineralisation hosted by mica schist and resembling the Lersletten prospect (J.P. Nielsen, pers. comm., 1991) show the same chemical characteristics, i.e. As, Sb, Zn, Mo, Se.

The third locality with weak indication of gold mineralisation lies east of the inner Arfersiorfik (sample no 360824-360826 in Table 1; Fig. 5). The samples were picked from a rust horizon observed during the drainage sampling and briefly visited. Less than 1 meter wide conformable sulphide rich bands are hosted by an east-west striking unit of amphibolite (s.l.) also containing biotite-garnet rich horizons. Besides sulphide, sample 360825 consists of staurolite, diopside, quartz and garnet, an assemblage which may represent original iron rich siliceous sediments (chemical sediments?) interleaved with basaltic volcanic rocks. It is noteworthy that the mineralised samples are free of As and Sb but contain Se.

Insufficient knowledge about the geological evolution of the Naternaq-Arfersiorfik district sets limits to the interpretation of the geochemical information provided by the stream sediment. However, the slightly elevated geochemical background for As, Sb and Au suggests that the sedimentary/volcano-sedimentary environment was syngenetically enriched in these elements. The character of the supracrustal sequences suggests a platform or intracratonic basin type of setting different from the setting north and south of Torsukattak.

The epigenetic mineralisation at the Lersletten prospect provides evidence for remobilisation of sulphides together with Au and Sb and possibly As. The remobilisation may have taken place during later deformation or during hydrothermal activity associated with the intrusion of late granites/pegmatites in the area.

A number of slightly elevated Au, As and Sb values in the Naternaq-Arfersiorfik district occurs in streams draining gneisses without supracrustal enclaves. This could be explained as the result of a regional remobilisation during which Au and other elements were removed from the original sedimentary/volcano-sedimentary hosts and emplaced in favourable structures in the surroundings such as fractures or shear zones in the gneisses.

The Naternaq-Arfersiorfik district appears to have a potential for gold mineralisation in that there are source rocks and signs of processes which are capable of moving and concentrating the gold. However, more basic geological mapping and isotope investigations as well as more exploration are highly warranted.

Conclusion

The distribution patterns of Au, As and Sb in stream sediment interpreted in relation to the geological setting of the supracrustal units and their known mineral occurrences suggest:

- Fairly strong syngenetic exhalative As+Sb+Au(+Cu?) enrichment in Archaean supracrustals of the Saqqaq-Torsukattak and Ataa districts followed by one ore more episodes of remobilisation producing epigenetic Cu-Au mineralisation in Archaean and overlying Proterozoic supracrustal units.

- Weak syngenetic Au+As+Sb+Zn(+Se?+Mo?) enrichment in presumed Archaean supracrustals of the Naternaq-Arfersiorfik district followed by remobilisation of unknown age to produce epigenetic Zn-Au? mineralisation.

- Au enrichment (-As -Sb) of unknown origin in supracrustals of the Christianshåb district. The absence of As+Sb is taken to indicate a different mineralisation situation than proposed for the other districts.

Acknowledgment

The sampling programme in the Naternaq-Arfersiorfik district was carried out by Jens P. Nielsen and Else Dam.

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The unpublished reports listed in the references are available for inspection at GGU. GGU can produce copies at cost.

Table 1. Element concentrations of grab samples of rusty horizons within the Naternaq - Arfersiorfik district.
Instrumental neutron activation analysis by Activation Laboratories Ltd.

GGU no.	Au ppb	As ppm	Ba ppm	Ca %	Co ppm	Cr ppm	Fe %	Mo ppm	Ni ppm	Rb ppm	Sb ppm	Se ppm	Th ppm	U ppm	Zn ppm
360807	40	52	400	0	66	33	38.70	79	270	0	7.6	12	0.6	17.0	1640
360811	0	0	0	0	0	20	0.25	0	0	0	0.0	0	0.0	0.0	104
360820	71	190	240	0	96	22	36.30	26	510	45	1.7	13	1.3	8.5	0
360821	0	30	1600	1	12	100	3.26	n.d.	0	110	0.5	0	7.8	5.1	127
360824	26	0	0	3	24	23	21.70	0	0	0	0.0	5	0.7	0.0	133
360825	269	0	0	4	20	26	20.40	0	0	0	0.0	7	0.0	1.1	120
360826	16	0	360	7	45	1100	7.95	0	180	0	0.6	0	5.4	0.0	149
360827	0	5	260	10	24	150	8.12	0	0	0	0.0	0	1.0	0.0	200
360828	0	0	0	26	0	0	0.65	0	0	0	0.0	0	0.0	0.0	0
360830	0	0	0	0	0	12	0.63	0	0	0	0.0	0	0.0	1.9	0

360807 massive pyrrhotite with sphalerite
360811 quartz vein
360820 massive sulphide
360821 mica schist
360824 sulphide rich layer in amphibolite
360825 sulphide rich layer in amphibolite
360826 amphibolitic host rock
360827 amphibolite
360828 carbonate
360830 quartzite with graphite

Table 2. Element concentrations of soil samples collected at the Lersletten sulphide mineralisation.
Instrumental neutron activation analysis by Activation Laboratories Ltd.

GGU no.	Au ppb	As ppm	Sb ppm	Ba ppm	Co ppm	Cr ppm	Fe %	Ni ppm	Th ppm	U ppm	Mo ppm	Se ppm
380050	0	6	0.0	330	69	66	4.37	0	3.3	1.3	0	0
380051	0	7	0.0	400	11	100	9.01	0	4.0	1.1	0	0
380052	5	13	0.4	360	9	87	10.70	0	4.4	0.0	0	0
380053	0	6	0.0	450	12	71	3.50	0	3.4	0.9	0	0
380054	0	2	0.0	420	10	65	2.98	0	3.2	4.5	0	0
380055	0	3	0.2	400	14	69	2.95	0	3.3	1.3	0	0
380056	0	14	0.4	430	13	76	5.71	0	3.2	1.1	0	0
380057	5	32	1.3	340	6	78	12.20	0	2.5	1.1	16	5
380058	0	17	0.6	320	12	78	7.78	0	2.8	0.7	7	5
380059	9	28	1.8	390	8	91	14.50	0	2.8	0.7	25	8
380060	13	17	0.0	470	40	120	4.50	160	7.7	2.5	0	0
380061	7	9	0.0	390	10	86	5.53	0	3.9	1.2	0	0
380062	0	10	0.0	410	14	74	3.02	97	4.1	1.0	0	0
380063	0	18	0.0	440	17	88	3.57	0	4.2	2.2	0	0

Figure 1. Geological setting of supracrustal units.

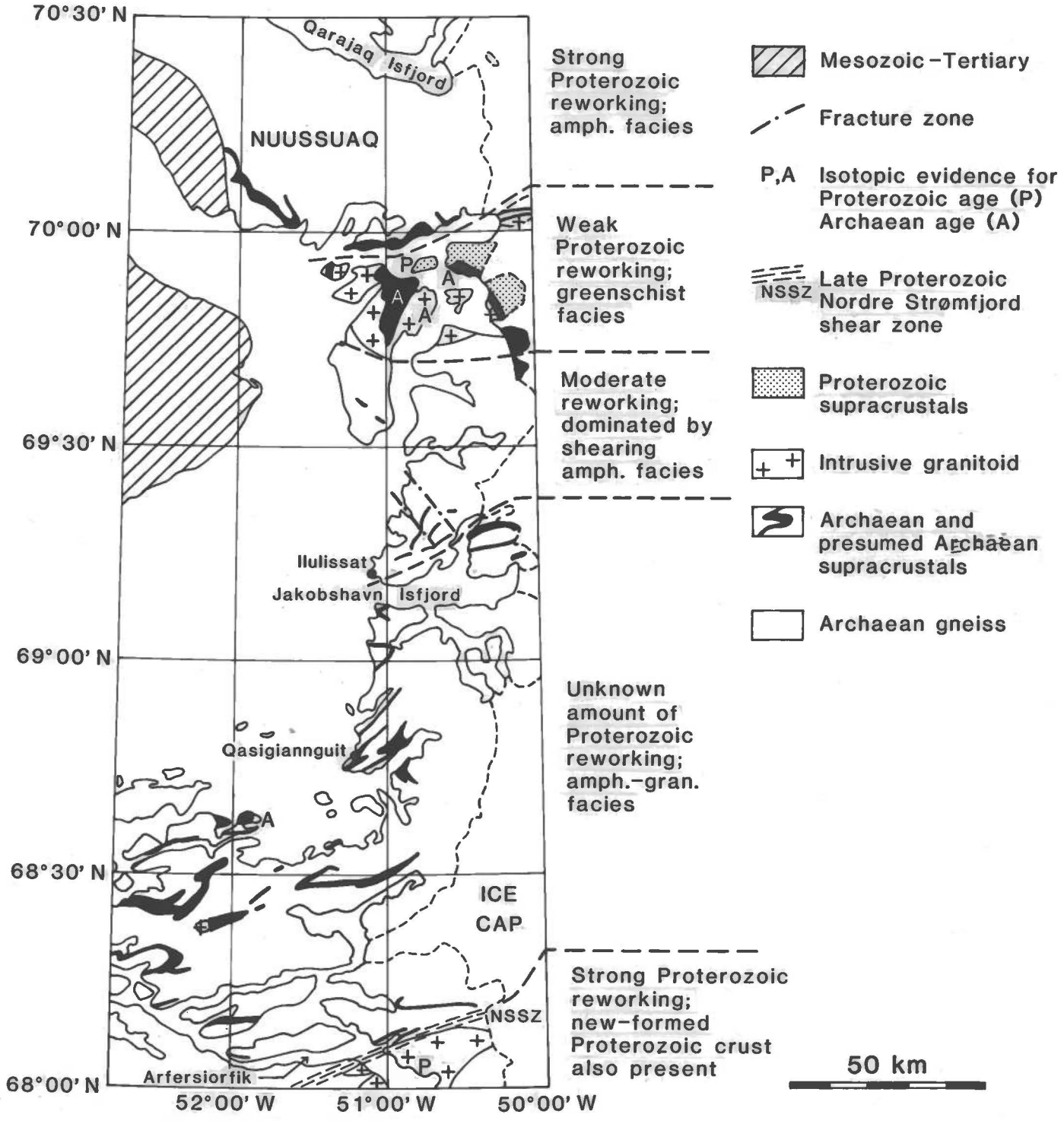
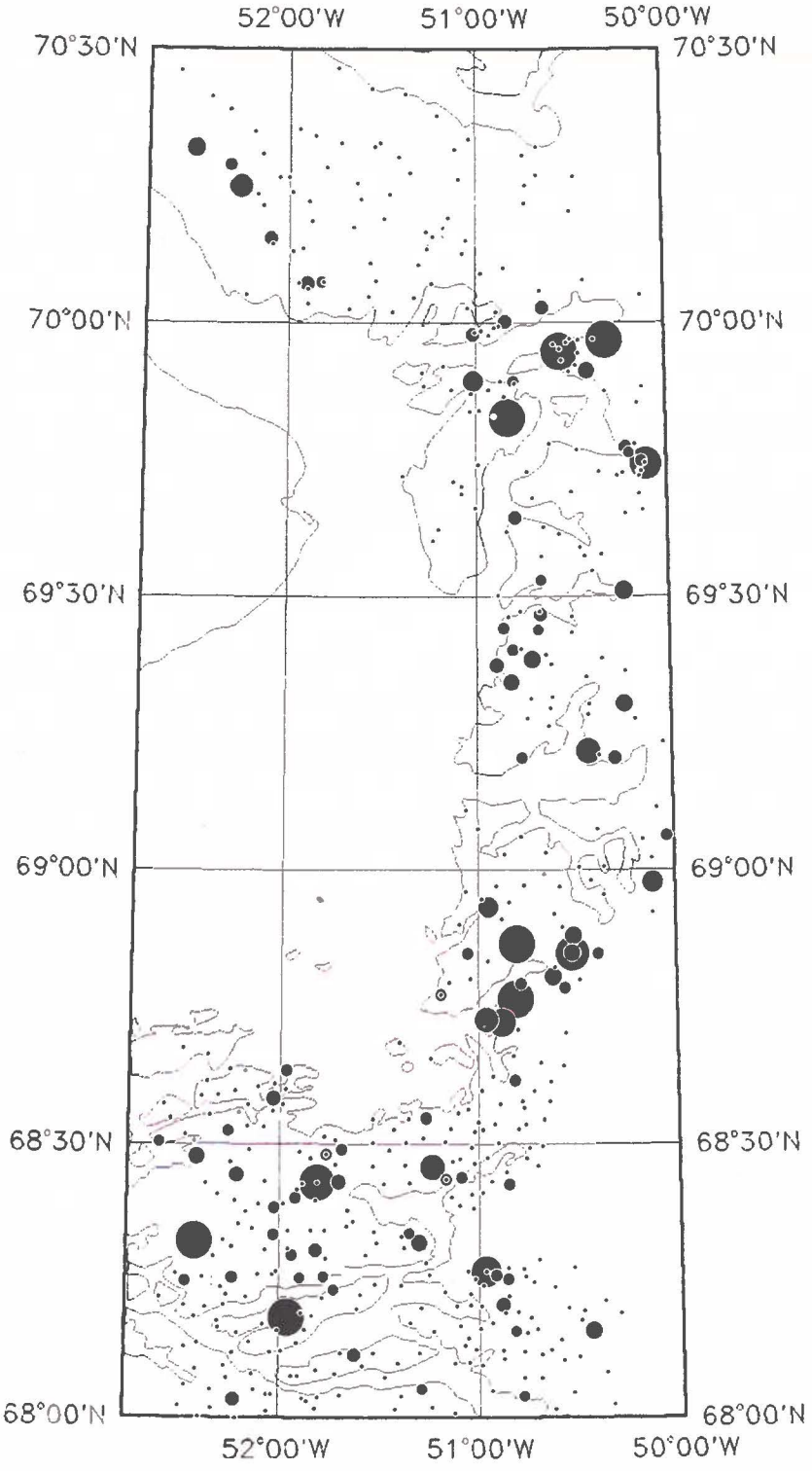
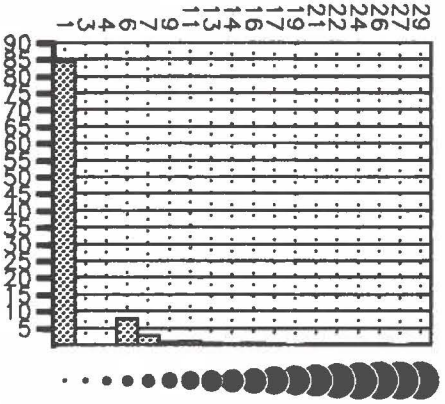


Figure 2.

Grønlands Geologiske Undersøgelse

Geochemical map: Au in stream sediment





Au ppb

Instrumental Neutron Activation Analysis

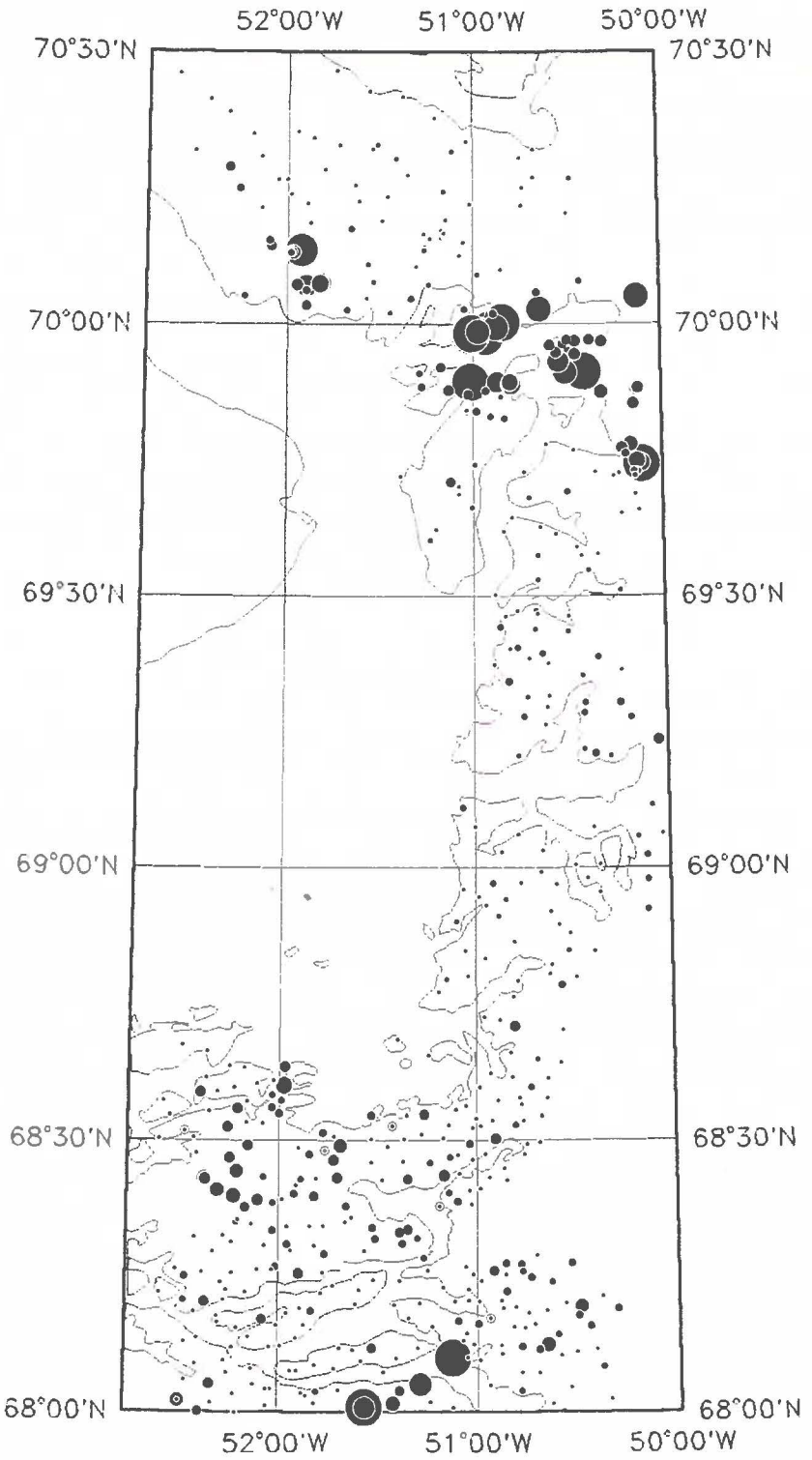
Number of samples:	566
Min. value:	0
Max. value:	115
Mean:	2
Median:	0
Variance:	55
Std. Dev.:	7

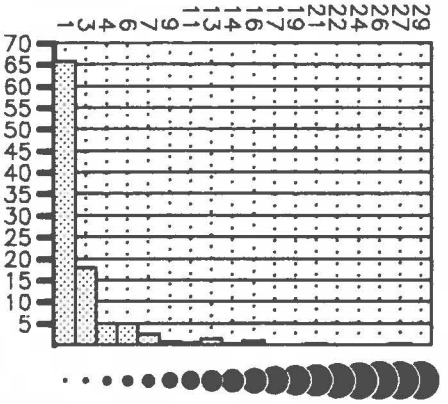
50 km

Figure 3.

Grønlands Geologiske Undersøgelse

Geochemical map: As in stream sediment





As ppm

Instrumental Neutron Activation Analysis

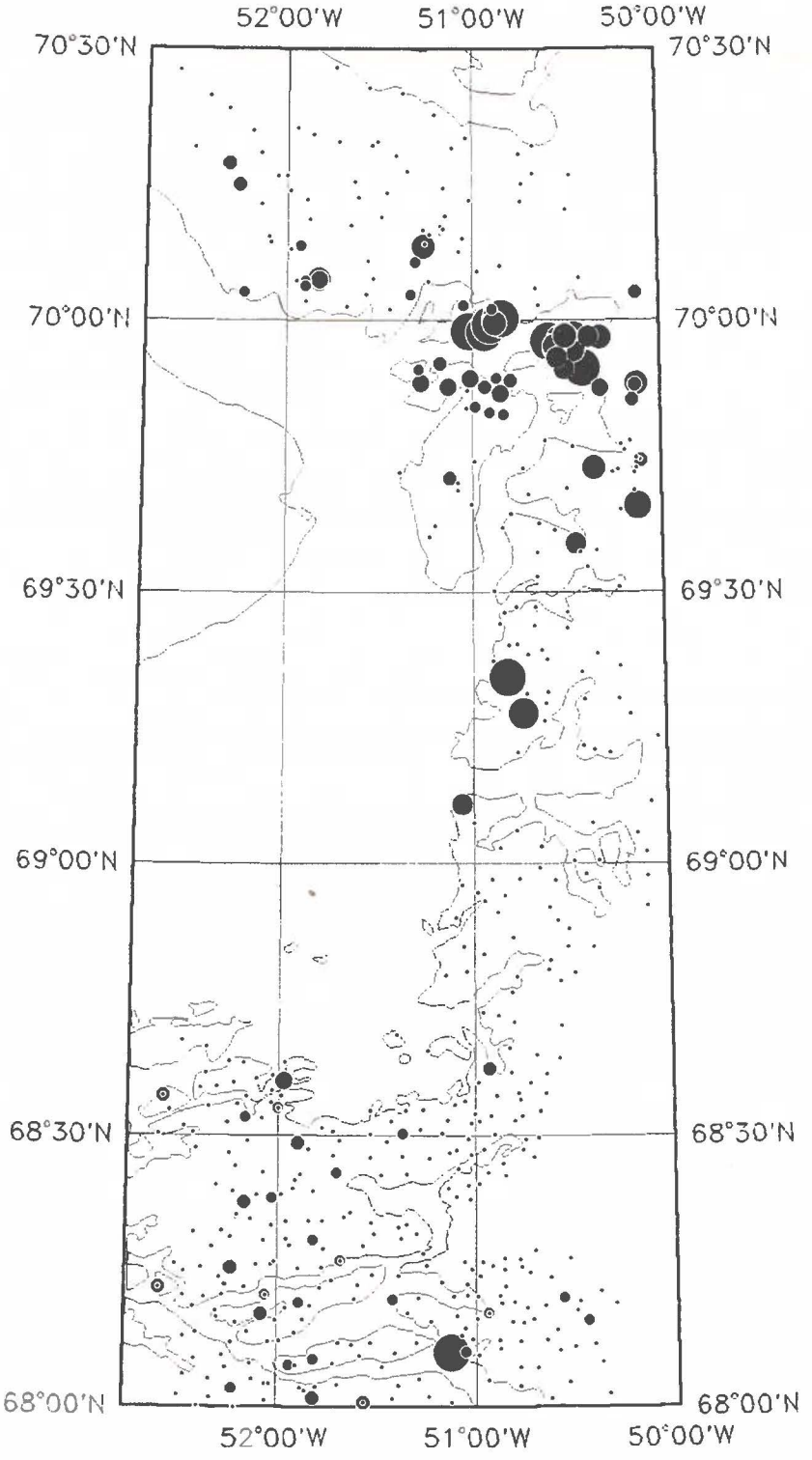
Number of samples:	566
Min. value:	0
Max. value:	717
Mean:	4
Median:	0
Variance:	1056
Std. Dev.:	32

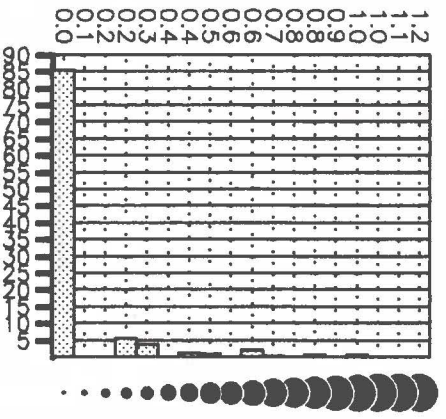
50 km

Figure 4.

Grønlands Geologiske Undersøgelse

Geochemical map: Sb in stream sediment





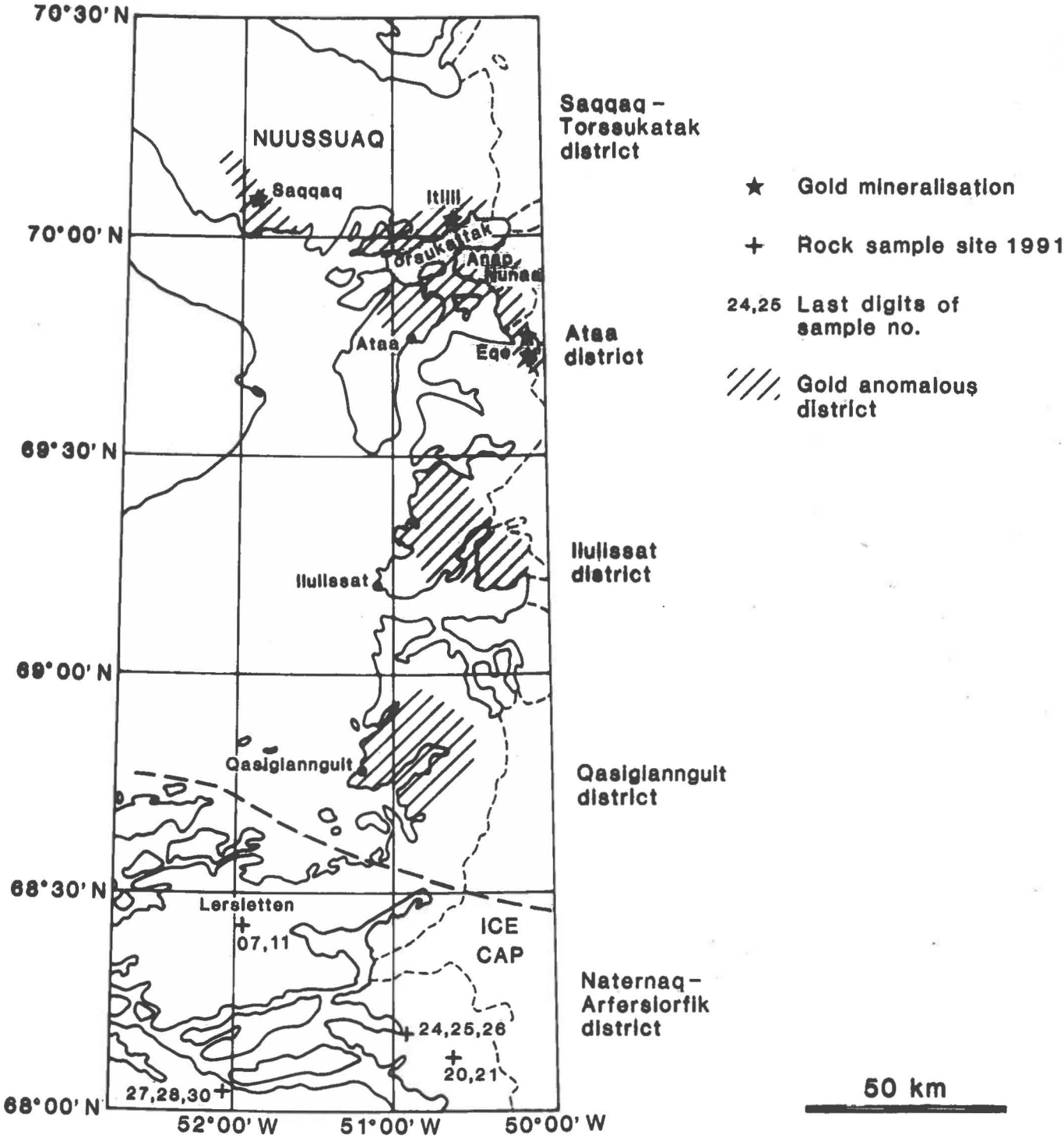
Sb ppm

Instrumental Neutron Activation Analysis

Number of samples:	566
Min. value:	0.0
Max. value:	36.4
Mean:	0.2
Median:	0.0
Variance:	3.3
Std. Dev.:	1.8

50 km

Figure 5. Place names, gold anomalous districts and gold mineralised sites.



ISSN 0903-7322