DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2005/39

Use of stream sediment and lithological data to estimate the chemical compositions of three land areas in South Greenland

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GEUS

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Abstract

This report is the result of a project jointly carried out by BMP and GEUS. It describes and discusses two ways of calculating the chemical composition of three land areas north of Nanortalik in South Greenland by means of data stored in GEUS' databases. The first method uses chemical data from systematically collected stream sediments, and the second uses chemical data from samples of major rock types together with their aerial coverage provided by a digital lithological map.

The study region was divided into drainage areas, and the composition of each has been calculated using the two methods. The resultant composition for each of the three main areas was determined as a mean of the subareas, weighted according their size.

The two approaches give comparable results illustrating the robustness of the methods, and the differences illustrate the advantages of using both types of data for a more complete result. However, additional samples and chemical analyses of these are necessary to improve the reliability of estimated compositions.

Data from individual drainage basins document the variation in local geochemical background that is important as a basis for evaluating an impact from non-natural activities.

The estimated compositions for large land areas may be viewed as a proxy for the composition of material deposited in adjacent fjords. In order to improve the prediction of the composition of fjord sediments, it is suggested to acquire chemical data for sediment deposited at the outlets of major streams and to measure the sediment load.

Introduction

The geochemistry of rocks, overburden and soil is fundamental for the understanding of the genesis and evolution of the Earth as well as for managing the surface environment. While geochemical data are widely applied on a local scale, the acquisition of systematic geochemical data with the objective of estimating the chemical composition of large areas is rarely undertaken.

Systematic collection and analysis of stream sediment samples have been carried out over large parts of Greenland, mainly for the purpose of mineral exploration. Element distribution maps based on compiled chemical data for West and South Greenland (Steenfelt 2001) illustrate that there is considerable chemical variation from one area to the next. The variation is observable in a qualitative way in the geochemical maps, but they do not provide quantitative documentation of the differences.

A stream sediment sample contains material from the surroundings of the stream above the sample point. In that way a stream sediment sample may be considered representative of the upstream drainage area. Although the composition of the weathered rock material deposited in streams depends on the interplay between many factors such as mineralogy, grain size, topography, climate and vegetation, stream sediment studies in Greenland show that the chemical variations in stream sediment usually reflect chemical variations in the rocks. Thus, it is possible to use stream sediment chemistry to estimate the chemical composition of an area.

Another way of estimating the chemical composition of an area is to use the chemistry of common rocks together with their aerial extent.

In this report, the chemical compositions of two peninsulas and one large island in South Greenland have been calculated, using both stream sediment and rock data. The results are compared and discussed, and their possible applications in environmental management are addressed.

Study region

The study region is situated in South Greenland, north of Nanortalik and comprises a landscape dominated by long, narrow SSW-trending fjords. The land surface of the peninsulas and islands between the fjords rises to altitudes above 1000 m with peaks up to 1800 m, and has a rugged topography with large, glacially eroded valley systems (Figure 1).

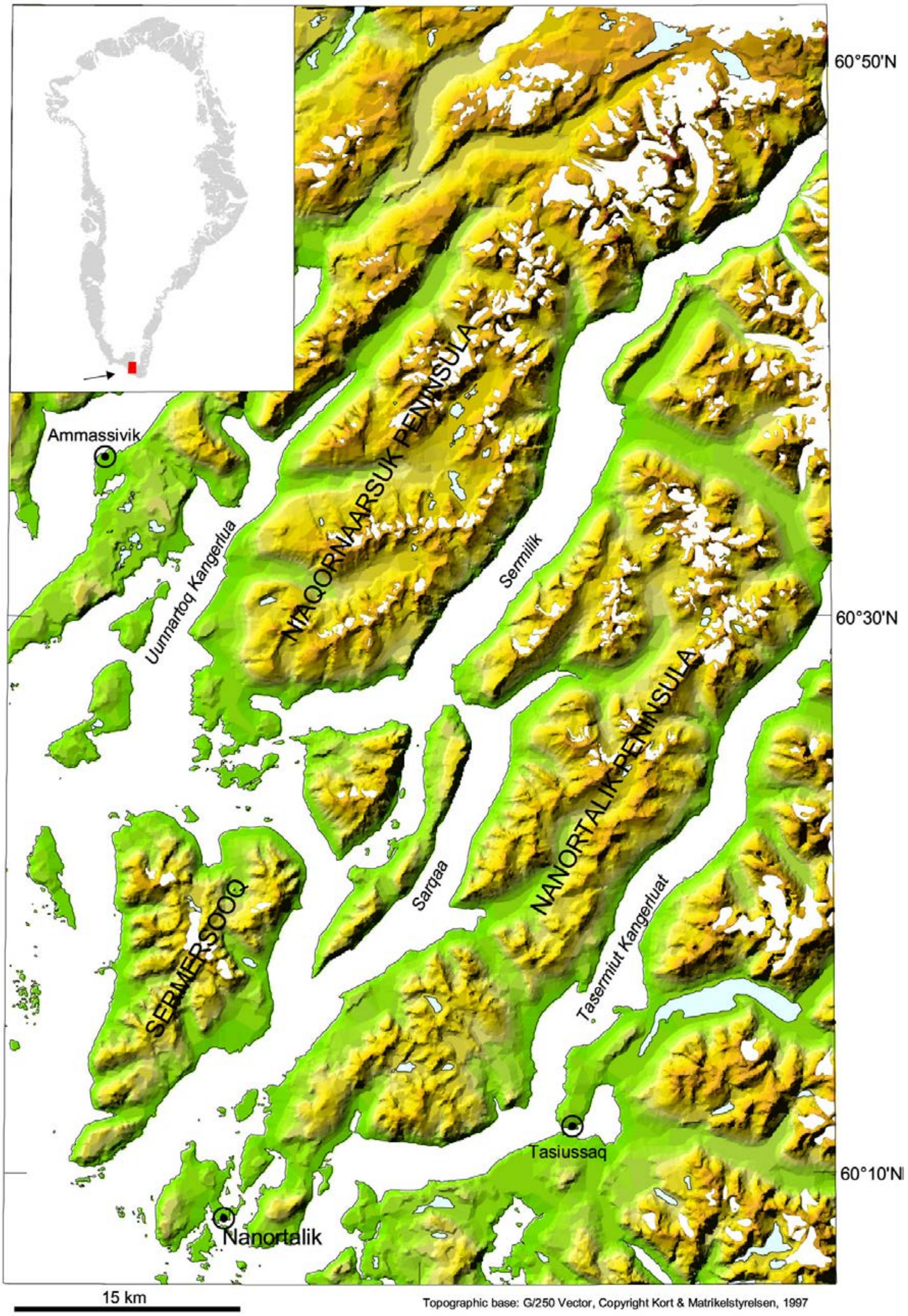


Figure 1. *Digital terrain model of the study area. The highest peaks in the north-eastern part of the area have an altitude of almost 2000 m.*

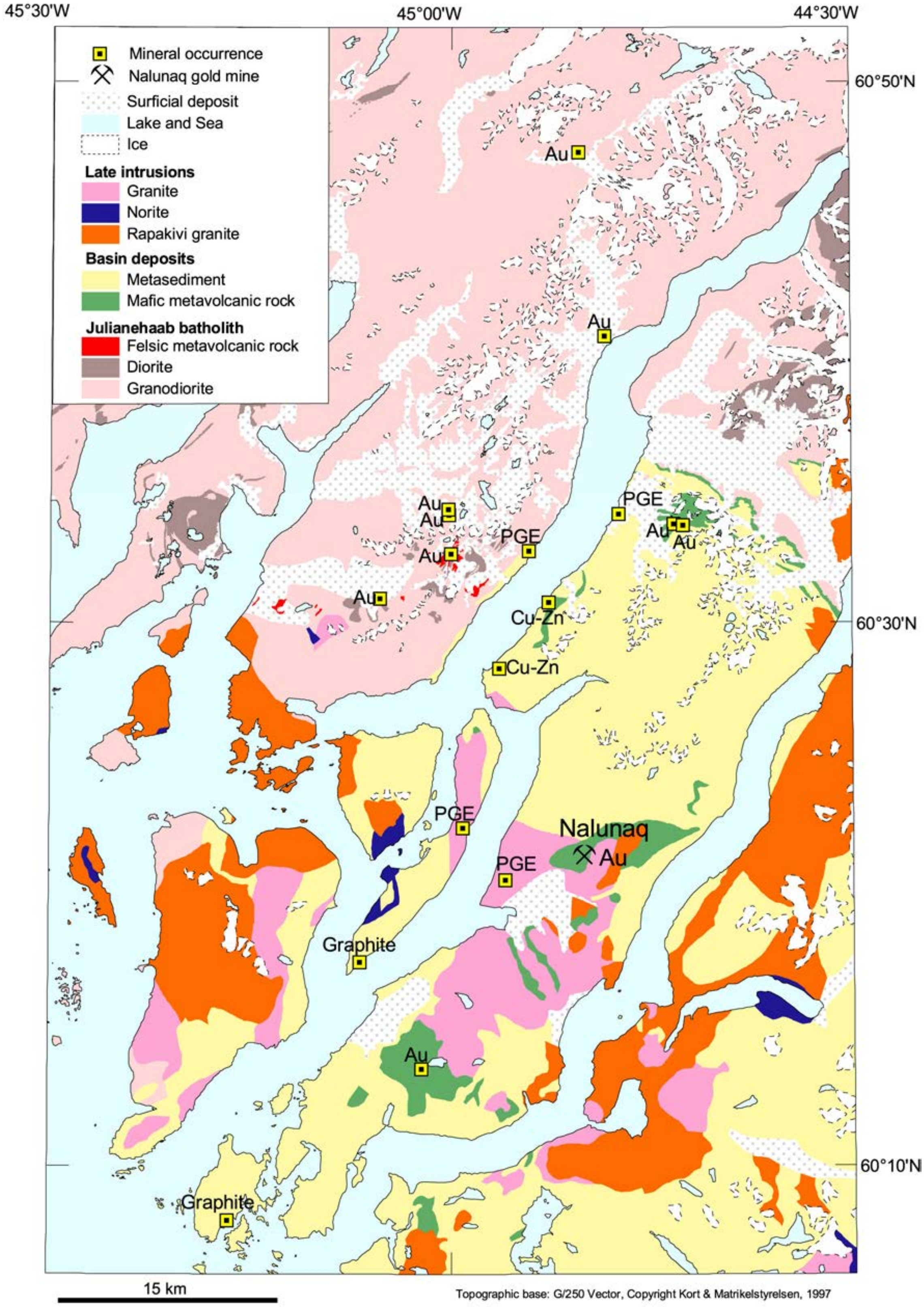


Figure 2. *Simplified geological map of the study area with known mineral occurrences based on (Allaart 1975) and Schjøth* et al. *(2000).*

Geologically, the area covers the boundary between the Julianehaab batholith to the NW and a volcano-sedimentary basin towards the SE (Figure 2), both formed during the Palaeoproterozoic Ketilidian orogeny (Kalsbeek *et al.* 1990). The batholith represents dioritic to granitic magmas consolidated in the root of a volcanic arc, and the volcanic and sedimentary rocks are believed to be the fillings of an oceanic fore-arc basin (Chadwick & Garde 1996; Garde *et al.* 1998). The fore-arc basin comprises deep-water pelitic sequences and mafic lavas as well as shallow water, flysch-type, psammitic sediments. Both batholith and volcano-sedimentary units were strongly deformed during the later phases of the orogeny. The batholith was transected by large, steep, NNE-trending shear zones, while deformation in the basin rocks resulted in flat-lying folds and thrusts that intercalated the deep and shallow water units. After the main deformation, the area was intruded by several generations of small granitic magmas and by dolerite and appinite dykes.

Geological mapping and mineral exploration was carried out by GEUS in parts of the study area during the Suprasyd project (Nielsen *et al.* 1993). The project was followed by a data compilation with the purpose of assessing the mineral potential of South Greenland (Schjøth *et al.* 2000; Steenfelt *et al.* 2000).

Several small mineral occurrences have been recorded within the study area (Figure 2, Schjøth *et al.* 2000). In the Niaqornaarsuk peninsula, gold mineralisation are encountered and described at four localities (Stendal *et al.* 1995; Stendal & Grahl-Madsen 2000) and mineral occurrence descriptions in the CD-ROM of Schjøth *et al.* 2000). In addition, gold bearing rock samples have been collected at a number of additional localities in the neighbourhood of the localities shown in Figure 2. The gold mineralisation is associated with zones of quartz veining and hydrothermal alteration following major shear zones. Besides gold, molybdenum, arsenic and lead are variably enriched in samples of the mineralised structures (Stendal *et al.* 1995).

In the Nanortalik peninsula, gold mineralisation is likewise recorded at four localities, one of which has been developed into an operating gold mine (Nalunaq, Figure 2). At Nalunaq, the gold, accompanied by arsenic minerals, is located in the vicinity of a NE-striking shearzone and is associated with quartz veins hosted by mafic metavolcanic rocks (Petersen *et al.* 1997). It is believed that the three other, less investigated, gold occurrences has the same setting. Other kinds of mineral occurrences in the Nanortalik peninsula comprise subeconomic copper and zinc sulphides in metasediments and platinum-group metals in small peridotitic bodies.

No mineral occurrences are recorded from Sermersooq, but conspicuous rust zones within the metapelite sequences suggest that iron sulphides are common.

Geochemically, the study area comprises the boundary between two provinces (Steenfelt *et al.* 2000). Many of the element distribution maps over South Greenland show a change in concentration level across a boundary zone that runs parallel to Sermilik. The boundary coincides with a boundary in the aeromagnetic map and reflects the margin of the batholith domain. The map of As is shown here to illustrate the geochemical zonation (Figure 3).

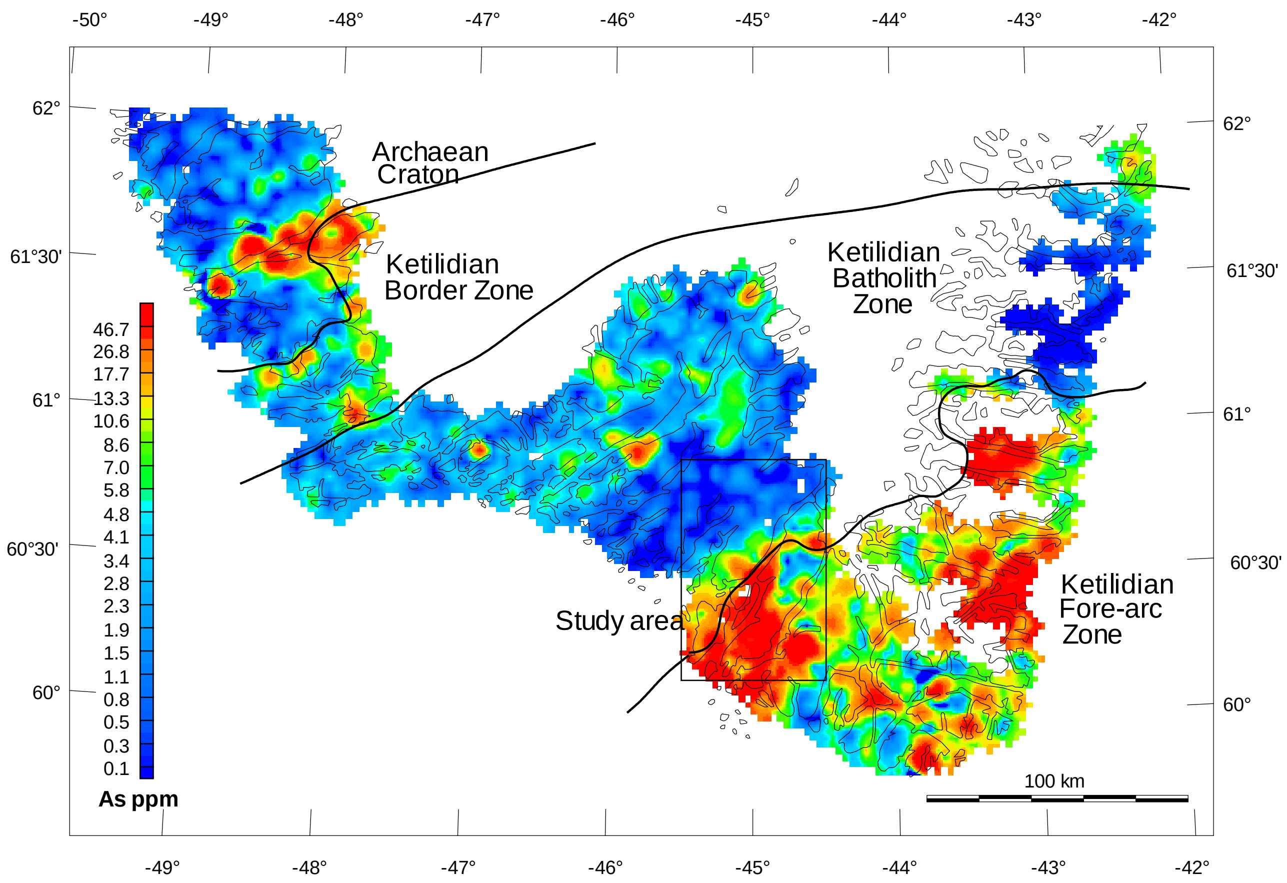


Figure 3. *Geochemical map of arsenic (As) in South Greenland as recorded by stream sediment chemistry. Major tectono-stratigraphic zones within the Ketilidian orogen are outlined together with the study region appearing in the following maps. From Steenfelt* et al. *(2000).*

Available data

Topographic data

A digital topographic data set in map scale 1:250 000 (G/250 Vector, Copyright Kort & Matrikelstyrelsen, 2001) has been used to produce the base map and the digital terrain model.

The projection parameters for the whole data set, is:

UTM-zone:	23 (*i.e.* the central meridian is 45° West)
False Easting:	500 000 metres
Geodetic reference:	WGS84

The digital terrain model (Figure 2) is made using ArcView 9.x TIN-extension (TIN = Triangulated Irregular Network). The digital topographic data set, including all valid 100-metre contour lines only on land, is used to create this model. The sea-polygon is added as a hard erase area to improve the visual display of the land area. The TIN-output is then converted to a grid with a cell-size of 25 metres using the ArcView extension Spatial Analyst. A hillshade relief with a simulated light source from 315°N and 45° declination is computed. The grid and the hillshade are then converted to an image using a free ArcView GIS 3.3 extension.

Lithological map

A geological map at 1:500 000 scale (Allaart 1975) has been revised and digitised as part of the Suprasyd project (Schjøth *et al.* 2000). The lithology of the study area has been extracted from this map (Figure 2). Dykes, faults and symbols appearing in the geological map have been omitted in the map used for the present study.

Stream sediment data

The study area has been covered with stream sediment samples at an average density of 1 sample per 6 km^2 during the Syduran project jointly undertaken by Geological Survey of Greenland (GGU) and Risø National Laboratory (Armour-Brown *et al.* 1982). The less than 0.1 mm fraction of the samples were originally (1979-80) analysed by Risø using isotope excited, energy dispersive X-ray fluorescence (XRF) and delayed neutron counting (DNC, Table 1). Later, remaining sample material was analysed again, first by Activation Laboratories for 33 trace elements using instrumental neutron activation technique (INA), and then at GGU (now GEUS) for major elements using XRF. Owing to insufficient amount of sample material, only a proportion of the original number of samples was analysed for major elements. The analytical data have been quality controlled and calibrated to form a consistent data set for South and West Greenland (Steenfelt 1999); Table 2). All sample location and analytical data are stored in a database at GEUS, from which all data derived from the study area have been extracted (Figure 4). Geochemical maps are displayed in three previous publications (Olesen 1984; Thorning *et al.* 1994; Schjøth *et al.* 2000).

Project holder	GGU/Risø	Nunaoil A/S	GGU/GEUS
Project name	Syduran		
Year of collection	1979	1990	1960-1996
Sample type	Stream sediment < 0.1 mm grain size fraction	Stream sediment heavy mineral fraction	Rock, mineralised rock
No of samples	204		308
Analysis 1, number	Risø XRF, 204	Actlabs INA, 304	GEUS XRF, 67
Analysis 2, number	Risø DNC, 204	Actlabs AAS (Aqua Regia extractable Cu,Pb), 304	Actlabs Au+48 (INA and ICP-ES), 243
Analysis 3, number	Actlabs INA, 139		Additional Actlabs INA, 52
Analysis 4, number	GEUS XRF, 66		

Table 1. *Overview of available samples and analytical data from the study region.*

XRF glass		XRF powder				INA		ICP	
GEUS		Risø plu		Risø cd		Actlabs		Actlabs	
	l.l.d.		l.l.d.		l.l.d.		l.l.d.		l.l.d.
						Ag	5	**Ag**	0.5
						As	2		
						Au	0.005		
Ba	100					**Ba**	100		
						Br	1		
								Cd	0.5
						Ce	3		
						Co	5		
Cr	50	**Cr**	50			**Cr**	10		
						Cs	2		
***Cu**	5	**Cu**	10					**Cu**	1
						Eu	0.2		
		Ga	10						
						Hf	1		
						Hg	1		
						Ir	5		
						La	1		
						Lu	0.05		
				(Mo)	20	**Mo**	5	**Mo**	2
(Nb)	50			**Nb**	20				
						Nd	5		
Ni	50	**Ni**	10			**Ni**	50	**Ni**	1
		(Pb)	10					**Pb**	5
Rb	50			**Rb**	20	**Rb**	30		
						Sb	0.2		
						Sc	0.1		
						Se	5		
						Sm	0.1		
						Sn	100		
Sr	50			**Sr**	20	**Sr**	500	**Sr**	1
						Ta	1		
						Tb	**0.5**		
						Th	0.5		
		****U**	0.016			**U**	0.5		
V	50	**(V)**	50					**V**	2
						W	4		
(Y)	100			**Y**	20			**Y**	2
						Yb	0.2		
Zn	50	**Zn**	10			**(Zn)**	50	**Zn**	1
Zr	50			**Zr**	20				

Lower limits of detection (l.l.d.) in ppm. Elements in blue are never or very rarely above l.l.d.
Elements in parentheses have poor precision.
** Cu determined by Atomic Absorption Spectrometry.*
*** U determined by Delayed Neutron Counting.*
Laboratories: GEUS *(Geological Survey of Denmark and Greenland);* Actlabs *(Activation Laboratories Ltd.);* Risø *(Risø National Laboratory).*
Methods: XRF *(X-ray Fluorescence Spectrometry);* plu *(XRF with plutonium source);* cd *(XRF with cadmium source);* DNC *(Delayed Neutron Counting);* INA *(Instrumental Neutron Activation);* ICP *(Inductively Coupled Plasma Emission Spectrometry).*

Table 2. *Elements determined in the < 0.1 mm grain size fraction of stream sediment samples collected by GGU/GEUS within the study region.*

Heavy mineral concentrates of stream sediment

The data originate from a geochemical survey carried out in twenty areas in South Greenland by Nunaoil A/S in 1990 (Olsen & Pedersen 1991) with the aim to confirm anomalous gold values obtained in GEUS stream sediments and pinpoint targets for gold exploration. The samples collected within the present study area cover most of the Niaqornaarsuk peninsula, but only the northern part of the Nanortalik area (Figure 5).

The raw samples consisted of 15–20 kg of unsorted stream sediment. After wet-sieving, a heavy mineral concentrate was produced from the <0.5 mm fraction on a vibrating gold screw. Subsequently the <0.25 mm fraction of the concentrate was analysed for 34 trace elements by instrumental neutron activation and for Cu and Pb by atomic absorption spectrometry after aqua regia digestion.

The analytical data and element distribution maps for the heavy mineral concentrates are included in the CD-ROM enclosed in Schjøth *et al.* (2000) and distribution maps were also presented in Thorning *et al.* (1994).

Rock data

South Greenland has been mapped geologically by GGU during the 1960s, and mapping and mineral exploration was undertaken again by GEUS in the Suprasyd project 1992–1996. Many of the samples collected in the earlier days have never been given a digital locality, and the far majority of analysed rock samples is provided by the Suprasyd project. The rock collection stored at GEUS (Table 1) reflects that the samples have been collected for specific purposes and at selected sites, so that the data coverage is far from systematic (Figure 6). Fresh unaltered samples of typical rock units are scarce. The majority of the rock samples has been collected for the purpose of mineral exploration and these samples are variably mineralised or altered. There is a scarcity of rock samples in the neighbourhood of Nalunaq, because fieldwork conducted by the Suprasyd project avoided areas covered by exploration licenses at the time.

Rock samples have been acquired in a number of different investigations, and they have been analysed according to purpose of sampling and methods available. The analytical data from these different sources have not been calibrated. The resulting chemical data, compiled during the Suprasyd project and stored in a GEUS database, are not entirely consistent. Most element concentrations have been determined using one or more of the methods X-ray fluorescence spectrometry (XRF), inductively coupled plasma emission spectrometry (ICP-ES), atomic absorption spectrometry (AAS), instrumental neutron activation analysis (INA). This means that several elements have been determined by more than one method, and commonly with slightly different results.

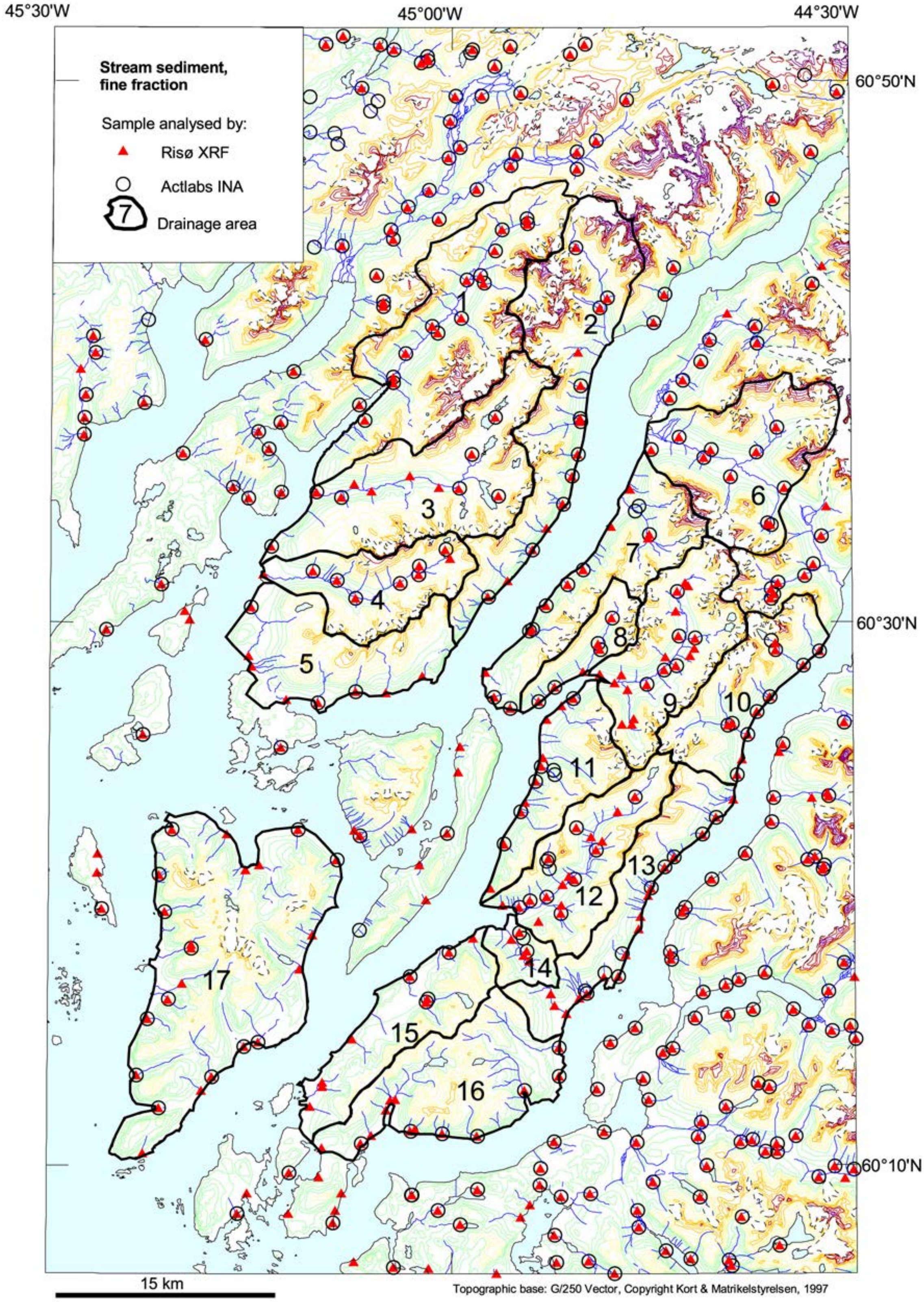


Figure 4. *Location of stream sediment samples with symbols indicating analytical treatment on topographical map with outline and numbering of drainage areas.*

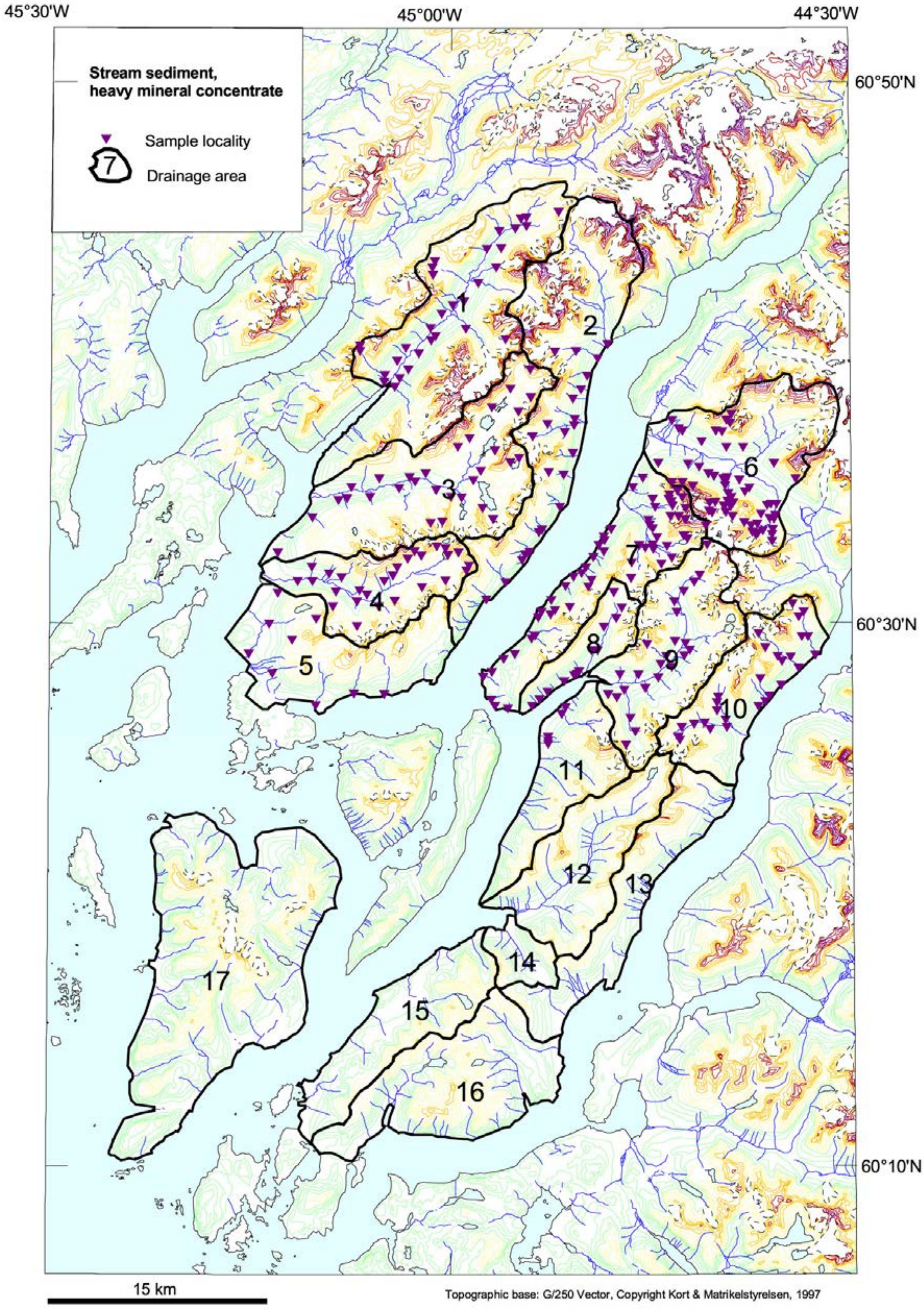


Figure 5. *Location of stream sediment samples collected by Nunaoil A/S and used for heavy mineral concentration on topographical map.*

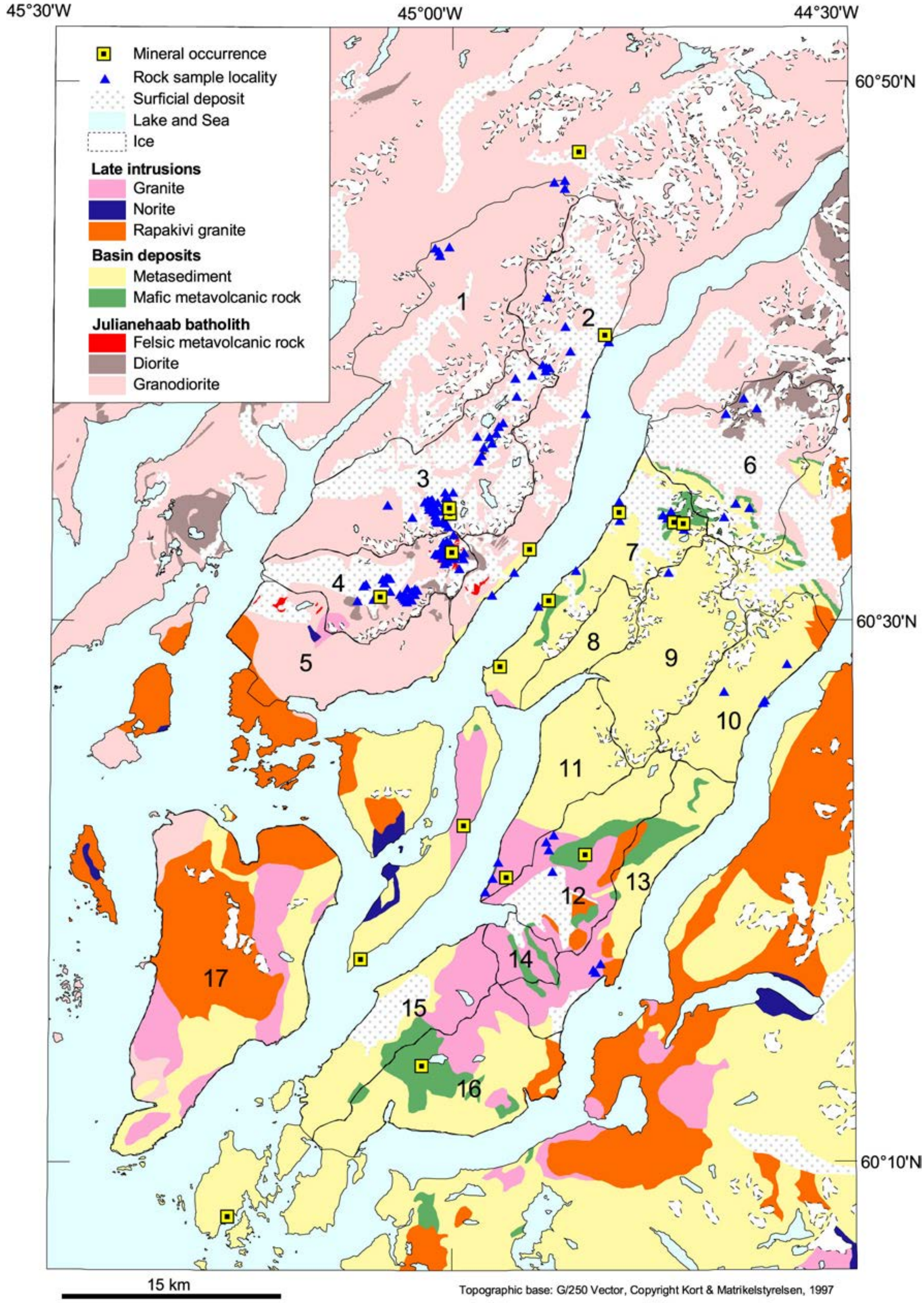


Figure 6. *Lithological map with outline and numbering of drainage areas and location of analysed rock samples. Lithology based on Allaart (1975) and Schjøth* et al*. (2000).*

Calculation procedures

Definition of drainage areas

The two peninsulas of the study area have been subdivided into 16 drainage areas. The major drainage basins (1,3,4,6,9,12 in Figure 4) were defined first, and then the remaining parts of the two peninsulas were divided into areas of similar size, each composed of a number of small drainage basins. The entire island of Sermersooq has been defined as an additional drainage area. Using ArcView software, the circumference of each of the seventeen drainage areas has been digitised using the topographical map with elevation contours (Figures 4,5 and 6).

Composition of drainage areas using stream sediment chemical data

The ArcView software has been used to calculate the size of each drainage area (Table 3) and to select data from all stream sediment samples collected within it. The main statistical parameters have been calculated for each drainage area and dataset (Risø XRF, Actlabs INA, GEUS XRF; Table 4a and 4b). It should be noted, though, that statistical parameters are not representative or very useful for small data populations. Element data that are largely below the lower detection limit, have poor precision or poor accuracy are omitted from the tables. The estimates for the composition of each peninsula (Table 5) have been expressed by means and medians calculated in two ways. In the first, each sample has been given equal weight. In the second, the medians and means for each catchment are weighted according to its size. The gross estimate in Table 5 combines the most reliable of the element data into one table.

Niaqornaarsuk		Nanortalik		Sermersooq	
Area no.	Size km^2	Area no.	Size km^2	Area no.	Size km^2
1	124.49	6	96.93	17	201.5
2	125.72	7	74.08		
3	122.93	8	25.32		
4	60.14	9	83.47		
5	80.17	10	62.83		
Total	498.21	11	53.84		
		12	73.08		
		13	66.22		
		14	16.48		
		15	66.2		
		16	94.75		
		Total	713.2		

Table 3. *Size of drainage areas. See location in Figure 4.*

	Stream sediment data, Niaqornaarsuk peninsula										Sermersooq	
Drainage	**1**		**2**		**3**		**4**		**5**		**17**	
	Mn.	**Md.**	**Mn.**	**Md.**	**Mn.**	**Md.**	**Mn.**	**Md.**	**Mn.**	**Md.**	**Mn.**	**Md.**
GEUSXRF												
Number	*9*		*8*		*3*		*6*		*1*		*2*	
SiO_2	63.6	64.8	63.6	63.4	53	52.8	57.3	55.4	64.4	64.38	56.79	56.79
TiO_2	0.87	0.87	1.06	1.08	1.2	1.02	0.93	0.83	0.65	0.65	1.02	1.02
Al_2O_3	14.8	14.7	14.6	14.5	15.4	14.7	15.1	15.9	14.3	14.33	16.64	16.64
Fe_2O_3	5.52	5.14	5.89	6.35	8.72	8.4	7.94	7.41	3.84	3.84	9.49	9.49
MnO	0.1	0.09	0.11	0.11	0.15	0.11	0.13	0.14	0.07	0.07	0.11	0.11
MgO	2.17	2.43	2.08	1.99	3.38	2.67	2.4	1.82	1.52	1.52	2.14	2.14
CaO	4.4	4.5	4.78	4.82	3.5	3.39	3.93	3.67	4.18	4.18	1.79	1.79
Na_2O	3.64	3.69	3.41	3.45	2.61	2.65	2.85	2.94	3.43	3.43	2.50	2.50
K_2O	2.09	1.9	2.21	2.34	2.25	1.98	2.2	2.15	1.83	1.83	4.06	4.06
P_2O_5	0.29	0.29	0.31	0.29	0.35	0.23	0.3	0.29	0.21	0.21	0.20	0.20
Vol.	2.08	1.63	1.32	0.69	8.94	10	6.8	5.78	5.05	5.05	5.19	5.19
Cr	7	6	15	7	37	15	28	24	8	8	39	39
Cu	20	17	17	15	45	45	31	26	11	11	49	49
Ni	32	24	23	23	37	42	24	22	21	21	38	38
Rb	51	48	75	56	97	77	90	73	52	52	262	262
Sr	413	445	326	336	296	291	361	357	394	394	146	146
V	68	68	78	80	103	118	61	48	44	44	60	60
Zn	73	58	70	61	179	151	132	137	56	56	211	211
Actlabs INA												
Number	*13*		*13*		*7*		*7*		*3*		*13*	
As	1.15	0	7	0	7.57	9	13.4	6	2.33	0	33.3	20
Au (ppb)	18	0	4.54	0	8.86	6	36.6	14	210	5	2.69	0
Ba	600	590	515	540	561	530	699	740	493	510	483	510
Co	14.9	13	15.9	14	16	14	16.6	18	14	13	16	16
Cr	60.8	43	56	49	51	41	51.1	39	52.3	56	40	38
Cs	0.31	0	2.62	3	3.57	2	4.14	5	2.33	3	5.46	5
Hf	10.6	10	18.5	16	7.86	9	8.29	8	17	16	39.4	16
Mo	0.54	0	0.92	0	0	0	0.86	0	4	0	0	0
Sb	0.07	0	0.14	0	0.31	0.3	0.39	0.5	0.27	0.4	0.16	0
Sc	16.8	17	20.3	21	16	16	18.7	18	18.3	16	14.6	13
Ta	0.15	0	1	0	0.14	0	0.14	0	0.33	0	0.54	0
Th	6.1	5.8	9.12	9.2	7.64	6.7	9.09	8	10.4	11	37	21
U	15.4	4	14	8.6	22	28	54.4	15	11.2	14	31.8	21
Zn	56.2	64	65	65	81.6	96	111	110	82.7	98	99	95
La	49	41	50	49	60	68	83	78	46	55	103	85
Ce	70	60	89	87	84	92	101	100	85	100	204	160
Nd	37	35	44	38	45	50	61	55	40	43	96	81
Sm	6.33	5.7	7.55	6.6	7.69	7.8	10.7	9.1	6.03	6.4	16.95	14
Eu	1.75	1.5	2.12	1.8	1.87	2	2.47	2	1.97	1.6	2.48	2.4
Tb	1.05	0.9	1.3	1.2	1.26	1.2	1.41	1.3	1.2	1.2	2.57	2
Yb	3.46	3.52	4.54	4.39	2.72	2.62	3.08	3.31	4.04	3.22	7.43	5.43
Lu	0.47	0.46	0.59	0.56	0.44	0.39	0.44	0.43	0.49	0.46	1	0.75
Risø XRF												
Number	*13*		*14*		*11*		*9*		*8*		*22*	
CaO	4.3	4.37	5.0	4.88	4.1	4.06	3.7	3.23	4.1	4.06	2.5	2.44
Cr	27	0	27	0	81	36	51	3	6	0	56	36
Cu	20	20	31	27	38	31	38	31	18	13.5	50	50
Fe_2O_3	7.2	6.92	9.0	9.34	10.2	9.95	10.6	9.32	6.6	6.68	10.4	10.05
Ga	17	16	21	22	23	22	23	21	16	16	26	26
K_2O	1.7	1.60	1.9	1.89	1.6	1.66	1.7	1.49	2.1	2.08	2.5	2.60
MnO	0.10	0.09	0.11	0.12	0.13	0.12	0.13	0.15	0.10	0.1	0.11	0.115
Nb	16	17	26	27	21	19	22	23	23	22	36	32
Ni	12	1	31	32	52	48	44	35	17	16	31	26
Pb	11	9	15	15.5	19	19	23	19	9	7	27	25
Rb	68	69	102	110	96	99	141	120	108	112	208	172
Sr	460	448	424	417	454	473	375	376	397	401	200	192
TiO_2	0.8	0.83	1.1	1.05	0.9	0.85	0.8	0.75	0.9	0.79	1.1	1.00
U	20	6	18	10	20	16	49	15	17	19	37	30
Y	43	41	57	53	37	36	44	46	43	39	85	60
Zn	84	73	109	116	154	146	177	151	90	92	151	132
Zr	346	330	574	500	323	345	414	287	596	552	1018	551

Table 4a. *Calculated statistical means (Mn.) and medians (Md.) for stream sediment chemical data within drainage areas of Niaqornaarsuk peninsula and Sermersooq. Number of analysis is shown in italics. See Table 2 for analytical methods. Major element oxides in %, trace elements in ppm, except Au. Vol. = volatiles.*

Stream sediment data, Nanortalik peninsula

Drainage	6		7		8		9		10		11		12		13		14		15		16	
	Mn.	Md.	Mn.	Md.	Mn.	Md.	Mn.	Md.	Mn.	Md.	Mn.	Md.	Mn.	Md.	Mn.	Md.	Mn.	Md.	Mn.	Md.	Mn.	Md.
GEUSXRF																						
Number	*7*		*3*		*2*		*3*		*5*		*4*		*6*		*5*		*0*		*1*		*1*	
SiO_2	58.9	59.4	68.4	68.5	65.8	65.8	68.9	66.8	63.4	64.8	65.2	65.4	57.7	58.6	61.4	60.7			50.6	50.6	59.1	59.1
TiO_2	1.08	1.09	0.63	0.67	0.63	0.63	0.4	0.36	0.57	0.54	0.53	0.53	0.69	0.75	0.69	0.7			1.08	1.08	0.63	0.63
Al_2O_3	14.8	15	13.3	13.4	14	14	13.6	14	15.1	14.2	13.3	13.1	13.5	14.1	14.2	14.1			14.7	14.7	12.5	12.5
Fe_2O_3	7.86	7.7	8.38	8.78	4.76	4.76	3.93	3.39	5	5.34	4.77	4.82	4.9	5.08	6.27	6.19			8.62	8.62	4.61	4.61
MnO	0.12	0.12	0.09	0.07	0.08	0.08	0.06	0.05	0.08	0.08	0.06	0.07	0.08	0.07	0.09	0.09			0.08	0.08	0.09	0.09
MgO	3.51	3.61	1.58	1.87	1.22	1.22	1.65	1.4	1.64	1.39	2.05	1.78	1.63	1.74	2.43	1.88			1.86	1.86	2.16	2.16
CaO	6.08	6.49	4.69	4.25	1.98	1.98	2.02	1.86	2.22	2.05	1.84	1.83	2.81	2.58	3.67	2.71			1.57	1.57	4.24	4.24
Na_2O	2.95	3.04	3.01	2.73	2.66	2.66	2.96	3.04	2.82	2.87	2.88	2.87	2.59	2.56	2.81	2.94			1.81	1.81	2.44	2.44
K_2O	1.63	1.84	2.3	2.54	4.01	4.01	4	3.92	3.72	3.69	3.67	3.68	3.22	3.45	3.08	2.9			2.82	2.82	1.91	1.91
P_2O_5	0.32	0.33	0.13	0.13	0.22	0.22	0.15	0.15	0.18	0.16	0.18	0.16	0.31	0.3	0.19	0.19			0.31	0.31	0.18	0.18
Vol.	2.41	1.24	0.96	0.77	4.3	4.3	2.29	3.06	5.01	3.05	5.22	4.74	12	10	5	4.07			16	16	11.8	11.8
Cr	58	53	98	117	33	33	103	65	69	71	149	86	54	36	109	104			117	117	128	128
Cu	34	37	23	20	25	25	14	12	18	14	30	30	41	40	47.8	41			34	34	28	28
Ni	40	43	30	27	24	24	32	21	27	25	40	33	31	33	51.2	40.5			38	38	38	38
Rb	71	79	80	82	127	127	109	111	134	127	127	128	131	135	113	99.2			202	202	61	61
Sr	330	342	307	283	267	267	261	260	278	265	252	255	225	214	244	257			247	247	269	269
V	115	117	79	67	33	33	30	27	37	40	36	37	52	45	84	60			110	110	111	111
Zn	89	91	67	72	62	62	15	6	49	34	34	34	94	98	64	72			190	190	86.3	86.3
Actlabs INA																						
Number	*9*		*10*		*5*		*6*		*10*		*7*		*11*		*10*		*3*		*4*		*6*	
As	17.9	9	67	33	10.4	7	3.33	3.5	18.8	4.5	10.3	6	42	34	16.2	13.5	405	59	66.3	66	53	52.5
Au	31.9	0	9.6	0	2.6	0	0	0	5.4	0	7.14	0	3.36	0	20.6	0	10	0	5	3.5	7.33	5.5
Ba	386	360	578	565	730	690	713	730	792	705	636	580	488	410	625	595	467	430	528	480	560	625
Co	22	23	20.3	14	8.4	9	6.83	4.5	9.9	10	9.29	7	13.4	12	14.7	12.5	18.3	19	11	10.5	19.8	17.5
Cr	93.8	100	115	60	74.2	47	171	109	85.2	89	112	87	59.5	53	102	89.5	60	56	45	43	79.3	74
Cs	5.33	4	5.4	5	7	6	7.67	5.5	5.3	4	6	6	9.18	7	7	5	6	5	9.25	8.5	4.5	4.5
Hf	12.8	12	9.2	8.5	10.8	10	11.3	6	13.3	13.5	10.3	10	13.1	12	17.4	13.5	22.7	28	16.8	14.5	21.5	20.5
Mo	0.67	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sb	0.74	0.8	1.32	1.4	1.7	1.7	1.25	1.2	0.71	0.85	1.56	1.6	1.1	1	1.59	1.25	7.97	7.3	0.9	1.05	0.68	0.7
Sc	23.4	23	16.7	14	8.42	8.1	7.85	7	8.73	8.6	7.81	7.7	15.1	16	13.9	12.5	17	16	13.7	13	17.5	16.5
Ta	0.33	0	0.47	0	0.2	0	0.17	0	0.7	0.5	0.71	0	0.82	0	1	0.5	1.33	2	0.25	0	0.5	0
Th	7.81	8.2	8.26	8.7	14	13	11.9	7.9	17.3	16.5	13.1	11	20.4	19	16.7	15	39.7	48	14.3	14	22.7	22
U	5.01	4.6	22.6	10.8	14	12	26.2	21	82.1	48.5	65.9	53	146	98	28	30	121	86	45.8	50.5	35.6	26
Zn	51	0	93	77	46	51	21	0	35	28	16	0	34	0	80	100	226	210	35	0	103	104
La	34	37	40	38	59	58	50	40	103	60	54	53	78	74	66	64	140	120	78	84	80	71
Ce	65	69	80	71	119	120	88	68	155	110	96	94	130	120	117	120	187	230	114	125	171	155
Nd	34	33	29	26	46	45	35	28	78	45	41	36	62	58	58	57	126	110	69	69	73	64
Sm	6.24	6.6	5.69	4.7	7.62	8	5.75	4.7	12.5	7.55	6.6	6.3	10.5	9.7	9.88	9.15	20.3	20	8.85	9.05	13.2	12.3
Eu	1.7	1.8	1.29	1.1	1.36	1.4	1.13	1.05	1.86	1.55	1.36	1.3	1.25	1.1	1.68	1.7	2.23	2.2	1.38	1.15	1.93	1.8
Tb	1.21	1.3	0.89	0.95	0.92	1	0.63	0.65	1.45	1.05	0.99	0.9	1.42	1.4	1.41	1.40	2.70	2.3	1.2	1.15	2.07	2.15
Yb	3.88	4.17	2.87	2.89	3.04	2.84	2.53	2.11	3.74	3.44	2.71	2.71	3.68	3.51	3.65	3.54	5.89	6.47	3.77	3.79	5.35	5.07
Lu	0.53	0.55	0.40	0.40	0.43	0.39	0.34	0.33	0.82	0.51	0.34	0.32	0.5	0.4	0.43	0.41	0.78	0.94	0.46	0.43	0.75	0.65
Risø XRF																						
Number	*10*		*12*		*6*		*19*		*11*		*10*		*16*		*17*		*5*		*9*		*12*	
CaO	5.6	5.51	3.0	2.71	1.9	1.93	2.2	2.00	2.2	2.27	1.8	1.78	3.7	3.63	3.2	2.85	2.9	2.57	2.5	2.10	3.9	2.85
Cr	57	38	51	0	14	0	83	0	3	0	19	0	20	0	43	0	0	0	3	0	48	0
Cu	35	33	31	28	15	15	11	6	18	13	21	22	51	37	32	21	38	26	16	14	59	46
Fe_2O_3	9.0	8.44	6.5	6.43	4.7	4.55	5.1	5.19	5.1	5.35	5.7	5.62	6.8	6.21	7.1	5.92	6.9	6.42	6.3	6.65	8.2	7.25
Ga	18	18	13	12	15	15	13	13	15	15	14	14	18	17	17	17	17	18	16	16	18	19
K_2O	1.7	1.82	2.5	2.58	3.8	3.79	3.4	3.42	2.9	3.22	3.4	3.43	2.8	2.82	2.4	2.20	2.3	2.53	2.1	2.12	2.0	2.11
MnO	0.12	0.12	0.08	0.07	0.06	0.07	0.06	0.06	0.07	0.07	0.06	0.06	0.08	0.08	0.08	0.08	0.07	0.07	0.05	0.05	0.10	0.08
Nb	20	23	16	16	20	20	19	20	21	21	25	24	27	25	22	22	30	27	24	23	19	17
Ni	21	19	34	32	22	25	40	22	30	28	27	19	37	31	39	31	13	5	18	19	51	44
Pb	17	16	14	16	7	6.5	11	11	10	9	10	8.5	17	15.5	14	14	13	11	13	12	14	16
Rb	94	103	125	123	185	179	166	161	176	168	194	199	188	195	152	140	172	176	158	161	138	139
Sr	369	395	268	271	264	264	271	260	269	288	264	262	231	204	244	262	207	203	185	168	198	167
TiO_2	1.1	1.10	0.7	0.73	0.7	0.60	0.6	0.55	0.6	0.60	0.7	0.71	0.8	0.88	0.8	0.80	1.1	1.02	0.9	0.83	0.8	0.87
U	7	7	25	14	14	12	26	19	70	45	45	38	105	43	24	21	38	31	34	24	53	26
Y	43	42	32	32	36	35	29	26	43	41	37	31	47	40	46	44	66	68	51	43	47	37
Zn	94	95	109	85	75	66	52	48	69	66	63	57	98	84	89	85	161	122	73	61	120	105
Zr	421	342	323	316	365	356	375	347	476	509	441	417	508	481	537	497	736	627	731	582	451	337

Table 4b. *Calculated statistical means (Mn.) and medians (Md.) for stream sediment chemical data within drainage areas of Nanortalik peninsula. Number of analysis are shown in italics. See Table 2 for analytical methods. Major element oxides in %, trace elements in ppm, except Au. Vol. = volatiles.*

	Niaqornaarsuk				Nanortalik				Sermersooq	
	Medians		Means		Medians		Means		Medians	Means
	sample based	*area based*	*sample based*	*area based*	*sample based*	*area based*	*sample based*	*area based*		
GEUS-XRF										
SiO_2	60.95	60.65	61.03	60.66	62.25	60.16	62.09	60.19	56.79	56.79
TiO_2	0.93	0.91	0.97	0.96	0.72	0.70	0.71	0.69	1.02	1.02
Al_2O_3	14.88	14.72	14.85	14.83	14.08	13.58	14.07	13.54	16.64	16.64
Fe_2O_3	6.32	6.21	6.46	6.33	5.96	5.87	5.93	5.87	9.49	9.49
MnO	0.11	0.10	0.11	0.11	0.08	0.08	0.09	0.08	0.11	0.11
MgO	2.16	2.15	2.31	2.33	2.04	1.96	2.14	2.03	2.14	2.14
CaO	4.27	4.19	4.30	4.21	3.25	3.16	3.41	3.29	1.79	1.79
Na_2O	3.33	3.27	3.27	3.23	2.81	2.64	2.79	2.64	2.50	2.50
K_2O	2.09	2.04	2.16	2.13	3.06	2.86	3.00	2.81	4.06	4.06
P_2O_5	0.28	0.26	0.30	0.29	0.22	0.21	0.23	0.21	0.20	0.20
Vol.	3.33	4.26	3.78	4.42	4.63	5.84	5.57	6.44	5.19	5.19
Rb	59	60	72	72	111	107	111	107	262	262
V	72	75	73	73	62	69	67	73	60	60
ACTLABS-INA										
As	2.4	2.7	6.0	5.7	22.5	25.4	44.3	40.9	33.3	20.0
Au ppb	3.6	3.8	28.9	45.8	0.6	1.1	10.3	10.4	2.7	<lld
Ba	584	570	577	565	559	558	593	582	483	510
Co	14	14	16	15	13	13	14	15	16	16
Cr	45	46	56	55	76	77	93	95	40	38
Cs	2.26	2.28	2.30	2.38	5.36	5.41	6.56	6.54	5.46	5.00
Hf	11.7	12.0	12.6	12.7	12.5	12.7	13.8	14.2	39.4	16.0
Sb	0.16	0.19	0.20	0.21	1.36	1.23	1.40	1.24	0.16	<lld
Sc	18.1	17.8	18.1	18.0	13.2	13.6	13.9	14.3	14.6	13.0
Th	7.7	8.0	8.1	8.3	14.9	14.4	15.6	15.2	37.0	21.0
La	55	56	56	55	59	58	67	65	103	85
Ce	83	85	84	84	108	107	116	114	204	160
Nd	42	43	45	44	47	47	55	54	96	81
Sm	6.92	6.90	7.61	7.41	8.18	8.14	9.23	9.03	16.95	14.00
Eu	1.76	1.76	2.01	1.99	1.43	1.43	1.53	1.53	2.48	2.40
Tb	1.13	1.14	1.23	1.23	1.24	1.27	1.29	1.29	2.57	2.00
Yb	3.58	3.47	3.64	3.62	3.52	3.58	3.61	3.68	7.43	5.43
Lu	0.47	0.47	0.50	0.50	0.46	0.46	0.52	0.52	1.00	0.75
RISØ-XRF										
Cu	25	24	29	30	23	25	30	31	50	50
Ni	26	25	31	32	27	27	33	33	31	26
Pb	14	14	15	15	13	13	13	13	27	25
Rb	100	99	100	101	157	152	158	152	208	172
Sr	426	429	426	443	250	254	253	257	200	192
U	12.5	12.4	24.1	23.4	25.7	24.6	42.3	40.6	37.2	29.6
Y	43.4	43.0	45.7	46.7	37.8	37.7	41.9	42.1	85.0	59.5
Zn	114	112	121	122	77	79	87	88	151	132
Zr	401	406	447	457	427	417	472	470	1018	551

Table 5. *Chemical composition of three main areas calculated as means and medians of analytical data for the <0.1 mm grain size fraction of stream sediment samples. Major element oxides in %, trace elements in ppm, except Au. Analytical methods, see Table 2. Vol.=volatiles.*

Composition of drainage areas using digital lithology and rock chemical data

The lithological composition of each drainage area has been approximated using the digital version of the lithological map of South Greenland (Schjøth *et al.* 2000). The study area comprises thirteen lithological map units besides icecaps and lakes (Table 6). Some of these have been grouped for the present purpose, see Table 6 and legend of Figure 2. The surface of each drainage area is composed of one or more of the mapped lithological units plus lakes, ice and surficial deposits. The surface areas of the three latter categories are proportioned between the lithological units according to a visual assessment of their probable substrate, so that the composition of each drainage area can be described in percentages of up to five lithological units (Table 7).

The estimation of the chemical composition of each lithology is the most difficult part of this approach. None of the rock sampling performed has had an objective of documenting the composition of the common rock types. The chemical data base for rock samples has been searched, and the most appropriate samples of each lithological unit has been selected, even if such samples were collected outside the study area. The median of element concentrations for each lithological group has been chosen to represent the chemistry of the group (Table 8). The full analytical data for the rock samples used are given in the appendix (Table A1).

Original map units		Simplified lithological division used in calculations	Simplified lithology used in Figure 2
Map code			
	Julianehaab batholith	**Julianehaab batholith**	**Julianehaab batholith**
404	Felsic metavolcanic rock	Felsic metavolcanic rock (404)	Felsic metavolcanic rock (404)
416	Diorite	Granodiorite (416+420)	Diorite (416)
420	Granodiorite	**Basin deposits**	Granodiorite (420)
	Basin deposits	Metasediment (502+506+508)	**Basin deposits**
506	Undifferentiated metasediment	Mafic metavolcanic rock (504+522)	Metasediment (502+506+508)
508	Metapsammite	**Late intrusions**	Mafic metavolcanic rock (504)
502	Metapelite	Granite (526+602)	**Late intrusions**
504	Mafic metavolcanic rock (amphibolite)	Rapakivi granite (606)	Diorite-gabbro (522+604)
	Late intrusions		Granite
522	Diorite-gabbro		Rapakivi granite
526	Late granite on Sermersooq		
602	Late granite on Nanortalik peninsula		Surficial deposits
604	Norite		
606	Rapakivi granite		
904	Surficial deposit		
10	Inland Ice		
20	Local ice cap		
40	Lake		

Table 6. *Lithological units in original map and those selected for the purpose of the present project.*

Adequate chemical data were not found for Julianehåb diorite (code416), hence the granodiorite and diorite has been treated as on group. Likewise, data for metapelite (code502), undifferentiated metasediment (code506), diorite (code522), and late granite on Sermersooq (code526) were lacking, and these units are represented by or grouped together with their chemically closest "relative" (see Table 6 and 7). The unit norite (code604) does not occur within the defined drainage areas.

Finally, the chemical composition of each drainage area has been calculated (Table 9) using the chemistry of the lithology groups (Table 8) in the proportions indicated in Table 7. It should be remembered that Tables 8 and 9 combine chemical data derived from several analytical methods and present the most reliable of the available data.

Drainage area	Lithology	Size km2	Allocated ice and lake	Allocated cover	Proportion	Percen-tage
1	420	124				100
2	20	17.22	0	0		
	404	0.45	0.45	0.45	0.004	0.36
	416	1.44	1.44	1.44	0.011	1.15
	420	59.23	76.45	120.79	0.964	96.36
	508+506	2.67	2.67	2.67	0.021	2.13
	904	44.34	44.34	0		
	Total	125.35		125.35	1	
3	420	123				100
4	20	3.15	0	0		
	404	1.18	1.18	1.18	0.020	1.96
	416	3.92	3.92	3.92	0.065	6.52
	420	25.22	28.37	53.56	0.891	89.07
	602	1.47	1.47	1.47	0.024	2.44
	904	25.19	25.19	0		
	Total	60.13		60.13	1	
5	20+40	0.44	0	0		
	404	0.61	0.61	0.61	0.008	0.76
	416+420	63.05	63.49	70.24	0.879	87.88
	506	0.93	0.93	0.93	0.012	1.16
	522	0.49	0.49	0.49	0.006	0.61
	606	7.66	7.66	7.66	0.096	9.58
	904	6.75	6.75	0		
	Total	79.93		79.93	1	
6	10	3.51				
	20	8.07	0	0		
	416	9.41	11.14	24.4	0.262	26.19
	420	11.29	11.94	51.75	0.555	55.55
	508+502	7.47	10.3	10.3	0.111	11.06
	504	3.88	6.71	6.71	0.072	7.20
	904	53.08	53.08	0		
	Total	93.16		93.16	1	
7	20	4.74	0			
	508	42.11	46.02	61.71	0.839	83.90
	504	6.7	7.53	10.66	0.145	14.49
	602	1.18	1.18	1.18	0.016	1.60
	904	18.83	18.83	0		
	Total	73.55		73.55	1	

Table 7. *Calculated proportions of lithological units within drainage areas.*

Drainage area	Lithology	Size km2	Allocated ice and lake	Allocated cover	Proportion	Percen-tage
8	508	25				100
9	508	83				100
10	20	5.91	0	0	0	
	504	0.09	0.09	0.09	0.001	0.14
	502+508	53.98	59.89	59.96	0.963	96.29
	606	2.22	2.22	2.22	0.036	3.57
	904	0.07	0.07	0		
	Total	62.27		62.27	1	
11	508	43.05	43.05	43.05	0.806	80.60
	602	10.36	10.36	10.36	0.194	19.40
	Total	53.41		53.41	1	
12	40	0.29	0	0		
	504	9.07	9.07	10.5	0.144	14.38
	508	22.15	22.44	22.44	0.307	30.72
	602	20.26	20.26	30.28	0.415	41.46
	606	6.96	6.96	9.82	0.134	13.44
	904	14.32	14.32	0		
	Total	73.04		73.04	1	
13	20	0.03	0.03			
	504	8.91	8.91	8.91	0.135	13.55
	508	32.6	32.6	32.6	0.496	49.57
	602	17.23	17.23	19.83	0.302	30.16
	606	4.42	4.42	4.42	0.067	6.72
		2.6	2.6	0		
	Total	65.76		65.76	1	
14	504	3.26	3.26	3.26	0.198	19.82
	602	11.38	11.38	13.19	0.802	80.18
	904	1.8	1.8	0		
	Total	16.45		16.45	1	
15	40	0.58	0	0		
	504	4.5	4.5	4.5	0.068	6.82
	508	28.39	28.39	41.08	0.623	62.29
	602	19.79	20.37	20.37	0.309	30.89
	904	12.69	12.69	0		
	Total	65.95		65.95	1	
16	40	0.89	0			
	504	18.45	19.09	19.09	0.203	20.25
	508	53.17	53.17	53.17	0.564	56.41
	602	16.45	16.7	16.7	0.177	17.72
	606	4.96	4.96	5.3	0.056	5.62
	904	0.34	0.34	0		
	Total	94.26		94.26	1	
17	10+40	1.49	0	0	0	
	420	15.20	15.20	15.20	0.076	7.61
	502	55.44	55.44	55.44	0.277	27.75
	526+602	41.27	41.65	41.65	0.208	20.85
	606	86.40	87.50	87.50	0.438	43.79
	Total	199.79		199.79	1	

Table 7 continued. *Calculated proportions of lithological units within drainage areas.*

It is evident that the procedure used here for obtaining the chemical composition of an area represents a crude approximation. It is based on a minimum of chemical data, and it does not take into account dykes and other unmapped rock units, the chemical variability within lithological units, nor the influence of known and unknown alteration and mineralisation. However, the chemical compositions obtained this way represent a kind of basic or minimum compositions that, after all, does prevail over large parts of the drainage areas. The calculation based on rock samples and lithology represents a different approach that is useful for comparison with the approach based on stream sediment data.

	Granodiorite	Felsic meta-volcanic rock	Late granite	Rapakivi	Amphibolite	Meta-psammite	Meta-pelite
Map code	420, 416	404	526, 602	606	504, 522	506, 508	502
Number of samples	*14*	*7*	*9*	*8*	*8*	*5*	*1*
SiO_2	66.74	73.91	68.92	62.54	51.30	70.38	*70.38
TiO_2	0.46	0.22	0.57	0.70	0.86	0.32	0.30
Al_2O_3	16.46	13.69	14.32	17.29	15.51	14.89	12.79
Fe_2O_3	3.70	2.80	4.11	7.88	11.74	3.10	4.72
MnO	0.06	0.07	0.04	0.07	0.21	0.06	0.05
MgO	1.01	0.55	0.75	0.85	5.48	0.67	2.22
CaO	3.81	1.21	1.70	3.07	7.57	2.48	2.83
Na_2O	4.45	3.14	3.01	3.50	2.67	4.15	1.15
K_2O	1.85	4.44	5.42	4.77	1.87	3.48	3.83
P_2O_5	0.18	0.07	0.20	0.25	0.25	0.09	0.08
Vol.	0.66	0.80	0.60	1.11	1.64	0.25	0.25
Ba	1029	993	916	1320	1201	1092	520
Cr	50	48	4	102	88	17	72
Cu	19	10	2	15	9	7	101
Ni	0	9	3	21	21	8	44
Rb	26	104	193	115	78	115	120
Sr	650	161	269	291	410	110	288
V	61	42		40	204	22	100
Zn	52	57	51	95	97	47	161
Zr	138	161	205	434	105	194	194
Pb	7.5	13.0	32.0	23.0	7.0	18.0	35.0
Y	12	16	22	42	14	10	7
As	1.3	2.1	0.0	4.5	1.4	2.0	13.0
Au	11.0	0.0	0.0	1.0	2.0	0.0	0.0
Co	35	12	27	8	37	9	13
Cs	1.1	2.0	5.2	2.5	4.0	2.0	4.0
Hf	5.3	6.0	4.3	8.8	2.5	5.1	4.0
Mo	0.75	0.00	0.00	0.00	0.00	0.00	0.00
Sb	0.50	0.40	0.00	0.35	0.70	0.20	0.50
Sc	5.8	10.1	4.5	11.1	36.0	4.9	11.0
Ta	0.30	0.40	1.50	1.15	0.00	0.90	0.90
Th	6.9	12.5	23.0	5.4	2.2	13.0	12.0
U	1.9	3.1	3.6	2.2	0.7	3.4	7.2
La	30	23	35	46	12	38	29
Ce	58	54	67	95	30	73	56
Nd	21	20	31	45	18	30	24
Sm	4.9	3.8	5.7	7.2	5.0	4.9	4.2
Eu	1.2	1.0	0.7	1.6	1.5	0.9	1.1
Tb	0.28	0.00	0.60	1.00	0.00	0.70	0.80
Yb	1.3	2.9	1.9	4.0	2.6	2.4	3.3
Lu	0.23	0.48	0.28	0.60	0.46	0.39	0.43

Table 8. *Chemical composition of lithological units determined as medians of element concentrations in selected rock samples.*
** SiO_2 and volatiles were not determined in this sample. The values have been estimated, so that the sum of oxides and volatiles is close to 100%.*

	Niaqornaarsuk peninsula							**Sermersooq**
Drainage	1	2	3	4	5	Weighted average		17
SiO_2	66.74	66.84	66.74	67.59	66.33	66.80	SiO_2	66.37
TiO_2	0.46	0.46	0.46	0.47	0.48	0.47	TiO_2	0.54
Al_2O_3	16.46	16.41	16.46	16.51	16.49	16.46	Al_2O_3	15.36
Fe_2O_3	3.70	3.69	3.70	3.73	4.14	3.77	Fe_2O_3	5.90
MnO	0.06	0.06	0.06	0.06	0.06	0.06	MnO	0.06
MgO	1.01	1.00	1.01	1.00	1.01	1.01	MgO	1.22
CaO	3.81	3.77	3.81	3.74	3.72	3.78	CaO	2.77
Na_2O	4.45	4.44	4.45	4.43	4.33	4.43	Na_2O	2.82
K_2O	1.85	1.89	1.85	2.00	2.16	1.92	K_2O	4.42
P_2O_5	0.18	0.18	0.18	0.18	0.19	0.18	P_2O_5	0.19
Vol.	0.66	0.65	0.66	0.67	0.70	0.66	Vol.	0.73
Ba	1029	1030	1029	1036	1058	1035	Ba	991
Cr	50	49	50	49	55	50	Cr	69
Cu	19	19	19	19	18	19	Cu	36
Ni	0	0	0	0	2	0	Ni	22
Rb	26	29	26	32	37	29	Rb	126
Sr	650	637	650	638	604	638	Sr	313
V	61	60	61	60	59	60	V	50
Zn	52	52	52	52	56	52	Zn	101
Zr	138	139	138	141	167	143	Zr	297
Pb	7.5	7.7	7.5	8.3	9.1	7.9	Pb	27.0
Y	12	12	12	12	15	12	Y	26
As	1.3	1.3	1.3	1.2	1.6	1.3	As	5.7
Au	11.0	10.7	11.0	10.6	9.8	10.7	Au	1.3
Co	35	34	35	34	32	34	Co	16
Cs	1.1	1.1	1.1	1.2	1.2	1.1	Cs	3.4
Hf	5.3	5.3	5.3	5.3	5.6	5.4	Hf	6.2
Mo	0.75	0.73	0.75	0.72	0.66	0.73	Mo	0.06
Sb	0.50	0.49	0.50	0.49	0.48	0.49	Sb	0.33
Sc	5.8	5.7	5.8	5.9	6.5	5.9	Sc	9.3
Ta	0.30	0.31	0.30	0.33	0.39	0.32	Ta	1.09
Th	6.9	7.0	6.9	7.4	6.8	6.9	Th	11.0
U	1.9	1.9	1.9	2.0	1.9	1.9	U	3.9
La	30	30	30	30	31	30	La	38
Ce	58	58	58	58	61	58	Ce	75
Nd	21	21	21	21	23	21	Nd	34
Sm	4.9	4.8	4.9	4.9	5.1	4.9	Sm	5.9
Eu	1.2	1.2	1.2	1.2	1.2	1.2	Eu	1.2
Tb	0.28	0.28	0.28	0.28	0.35	0.29	Tb	0.81
Yb	1.3	1.3	1.3	1.4	1.6	1.4	Yb	3.2
Lu	0.23	0.23	0.23	0.24	0.27	0.24	Lu	0.46

Table 9a. *Chemical composition for drainage areas within Niaqornaarsuk peninsula and Sermersooq estimated by means of lithological composition and rock chemistry.*

Nanortalik peninsula

Drainage	6	7	8	9	10	11	12	13	14	15	16	Weighted average
SiO_2	66.03	67.58	70.38	70.38	70.07	70.10	65.98	66.83	65.43	68.63	65.82	67.79
TiO_2	0.48	0.40	0.32	0.32	0.33	0.36	0.55	0.49	0.63	0.43	0.49	0.43
Al_2O_3	16.21	14.97	14.89	14.89	14.97	14.78	15.06	14.96	14.56	14.75	15.05	15.10
Fe_2O_3	4.22	4.37	3.10	3.10	3.28	3.30	5.40	4.90	5.62	4.00	5.30	4.25
MnO	0.07	0.08	0.06	0.06	0.06	0.05	0.07	0.07	0.07	0.06	0.09	0.07
MgO	1.29	1.36	0.67	0.67	0.68	0.68	1.42	1.36	1.69	1.02	1.66	1.16
CaO	3.93	3.20	2.48	2.48	2.50	2.32	2.97	2.97	2.86	2.58	3.40	2.98
Na_2O	4.29	3.92	4.15	4.15	4.12	3.93	3.38	3.56	2.94	3.70	3.61	3.85
K_2O	2.03	3.28	3.48	3.48	3.52	3.86	4.22	3.93	4.72	3.97	3.57	3.50
P_2O_5	0.18	0.12	0.09	0.09	0.10	0.11	0.18	0.16	0.21	0.13	0.15	0.14
Vol.	0.68	0.46	0.25	0.25	0.28	0.32	0.71	0.60	0.81	0.45	0.64	0.50
Ba	1048	1104	1092	1092	1100	1057	1065	1069	972	1045	1095	1074
Cr	49	27	17	17	20	15	33	28	21	18	34	28
Cu	17	7	7	7	7	6	6	6	3	6	7	8
Ni	2	10	8	8	8	7	10	9	7	7	10	8
Rb	40	111	115	115	114	130	142	133	170	136	121	114
Sr	573	156	110	110	117	141	243	211	297	180	209	228
V	67	48	22	22	23	18	41	41	40	28	56	40
Zn	54	54	47	47	49	48	62	58	60	52	61	54
Zr	142	181	194	194	202	196	218	201	185	191	191	189
Pb	8.6	16.6	18.0	18.0	18.2	20.7	22.9	21.1	27.0	21.6	18.5	18.2
Y	12	11	10	10	11	12	20	16	20	14	15	13
As	1.3	1.9	2.0	2.0	2.1	1.6	1.4	1.5	0.3	1.3	1.7	1.6
Au	9.1	0.3	0.0	0.0	0.0	0.0	0.4	0.3	0.4	0.1	0.5	1.4
Co	32	13	9	9	9	12	20	18	29	16	18	17
Cs	1.4	2.3	2.0	2.0	2.0	2.6	3.7	3.3	5.0	3.1	3.0	2.6
Hf	5.1	4.7	5.1	5.1	5.2	4.9	4.9	4.8	3.9	4.7	4.6	4.9
Mo	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Sb	0.48	0.27	0.20	0.20	0.21	0.16	0.21	0.22	0.14	0.17	0.27	0.25
Sc	7.8	9.4	4.9	4.9	5.2	4.8	10.0	9.4	10.7	6.9	11.5	7.9
Ta	0.34	0.78	0.90	0.90	0.91	1.02	1.05	0.98	1.20	1.02	0.84	0.85
Th	7.2	11.6	13.0	13.0	12.7	14.9	14.6	14.0	18.9	15.3	12.1	12.7
U	2.0	3.0	3.4	3.4	3.4	3.4	2.9	3.0	3.0	3.3	2.8	3.0
La	30	34	38	38	38	37	34	34	31	35	33	35
Ce	57	67	73	73	74	72	67	67	60	68	64	67
Nd	21	28	30	30	31	30	31	30	28	29	29	28
Sm	4.9	4.9	4.9	4.9	5.0	5.0	5.5	5.3	5.5	5.1	5.2	5.1
Eu	1.2	1.0	0.9	0.9	0.9	0.9	1.0	1.0	0.9	0.9	1.0	1.0
Tb	0.30	0.60	0.70	0.70	0.71	0.68	0.60	0.60	0.48	0.62	0.56	0.58
Yb	1.5	2.4	2.4	2.4	2.5	2.3	2.4	2.4	2.0	2.2	2.4	2.3
Lu	0.26	0.40	0.39	0.39	0.40	0.37	0.38	0.38	0.32	0.36	0.40	0.37

Table 9b. *Chemical composition for drainage areas within Nanortalik peninsula estimated by means of lithological composition and rock chemistry.*

Comparison of calculated compositions

In order to facilitate the comparison of the data and discuss differences, the elements are grouped and the calculated data are presented in diagrams. Six groups are used, 1) major components and volatiles, 2) trace elements associated with felsic rocks, 3) trace elements associated with mafic rocks, 4) trace elements associated with sulphide and gold mineralisation, 5) trace elements mainly associated heavy minerals, and 6) rare earth elements (REE). The grouping of the elements Cu, Ni and Zn is a matter of opinion as these elements are contained in both rock-forming minerals (i.e. silicates) and in sulphides. The data obtained in this study suggest that the median concentrations of Cu and Ni reflect the abundance in common mafic rocks, while elevations in Zn in some drainage areas seem to reflect Zn mineralisation. REE (La to Sm) are mostly hosted by heavy minerals (e.g. garnet, monazite, epidote, allanite, sphene) although some (Eu to Lu) are also hosted by rock-forming minerals (hornblende, mica).

Difference between methods

Difference between medians and means in stream sediment data

Although the populations studied (element concentrations for a group of samples) are rarely normally distributed in a statistical sense, the ‘median’ and ‘mean’ of a population is a commonly used way of expressing the average situation for the population (Table 4). Generally speaking, the median expresses the typical concentration, while the mean is the average concentration where each sample has equal weight. In the present situation, where we are dealing with a small number of samples in each drainage area, the mean will be biased by any sample(s) with uncharacteristic concentration. In other words, the median may be taken to represent the geochemical background. If the mean is close to the median, the variation within the population is small. Many trace elements have log-normal frequency distributions because they reflect the presence of special rock types or mineralisation within a given area, and in that case their mean concentrations are larger than their median concentrations. Thus, where the mean is very different from the median, it indicates that the drainage area contain mineralisation or other kinds of unusual rocks.

Difference between stream sediment and rock data

Table 10 contains the estimated compositions using the two methods for the three main areas of this study as well as for the total area. The estimates for the total area represent the average weighted according to the size of the three main areas. The diagram in Figure 7 shows the ratio between stream sediment and lithochemical estimates for the total area. It should be remembered that major and some trace element data for stream sediment samples from Sermersooq are based on only two samples (see Table 4). Lithochemical and stream sediment geochemical compositional estimates for each drainage area are given next to each other in a table in the Appendix (Table A2).

	Niaqornaarsuk		Nanortalik		Sermersooq			Total	
	SS	Lith	SS	Lith	SS	Lith		SS	Lith
SiO_2	60.65	66.80	60.16	67.79	56.79	66.37	SiO_2	59.85	67.24
TiO_2	0.91	0.47	0.70	0.43	1.02	0.54	TiO_2	0.82	0.46
Al_2O_3	14.72	16.46	13.58	15.10	16.64	15.36	Al_2O_3	14.42	15.62
Fe_2O_3	6.21	3.77	5.87	4.25	9.49	5.90	Fe_2O_3	6.51	4.32
MnO	0.104	0.058	0.079	0.068	0.114	0.056	MnO	0.09	0.06
MgO	2.15	1.01	1.96	1.16	2.14	1.22	MgO	2.05	1.11
CaO	4.19	3.78	3.16	2.98	1.79	2.77	CaO	3.32	3.23
Na_2O	3.27	4.43	2.64	3.85	2.50	2.82	Na_2O	2.84	3.91
K_2O	2.04	1.92	2.86	3.50	4.06	4.42	K_2O	2.74	3.07
P_2O_5	0.26	0.18	0.21	0.14	0.20	0.19	P_2O_5	0.23	0.16
Vol.	4.26	0.66	5.84	0.50	5.19	0.73	Vol.	5.19	0.59
Ba	570	1035	558	1074	510	991	Ba	555	1048
Sr	429	638	254	228	192	313	Sr	307	384
Rb	60	29	107	114	262	126	Rb	113	86
Cs	2.3	1.1	5.41	2.6	5	3.4	Cs	4.2	2.2
Sc	17.8	5.9	13.6	7.9	13.0	9.3	Sc	15.0	7.4
V	75	60	69	40	60	50	V	70	48
Cu	24	19	25	8	50	36	Cu	28	16
Co	14	34	13	17	16	16	Co	14	23
Ni	25	0	27	8	26	22	Ni	26	7
Cr	46	50	77	28	38	69	Cr	61	42
Pb	13.7	7.9	13.2	18.2	25.0	27.0	Pb	15.0	15.8
Zn	112	52	79	54	132	101	Zn	98	60
Au	3.8	10.7	1.1	1.4	0.1	1.3	Au	1.9	4.7
As	2.7	1.3	25.4	1.6	20.0	5.7	As	16.6	2.1
Sb	0.19	0.49	1.23	0.25	0.05	0.33	Sb	0.69	0.35
Hf	12.0	5.4	12.7	4.9	16.0	6.2	Hf	12.9	5.2
Th	8.0	6.9	14.4	12.7	21.0	11.0	Th	13.1	10.4
U	12.4	1.9	24.6	3.0	29.6	3.9	U	21.0	2.7
Y	43	12	38	13	60	26	Y	43	15
Zr	406	143	417	189	551	297	Zr	433	188
La	56	30	58	35	85	38	La	61	34
Ce	85	58	107	67	160	75	Ce	107	65
Nd	43	21	47	28	81	34	Nd	51	27
Sm	6.9	4.9	8.1	5.1	14.0	5.9	Sm	8.5	5.1
Eu	1.76	1.20	1.43	0.98	2.40	1.25	Eu	1.7	1.1
Tb	1.14	0.29	1.27	0.58	2.00	0.81	Tb	1.33	0.51
Yb	3.47	1.36	3.58	2.26	5.43	3.16	Yb	3.8	2.1
Lu	0.47	0.24	0.46	0.37	0.75	0.46	Lu	0.51	0.33

Table 10. *Chemical composition of three main areas estimated by means of stream sediment data (SS) and lithochemical data (Lith), respectively. The composition of the total area is an average weighted according to area size.*

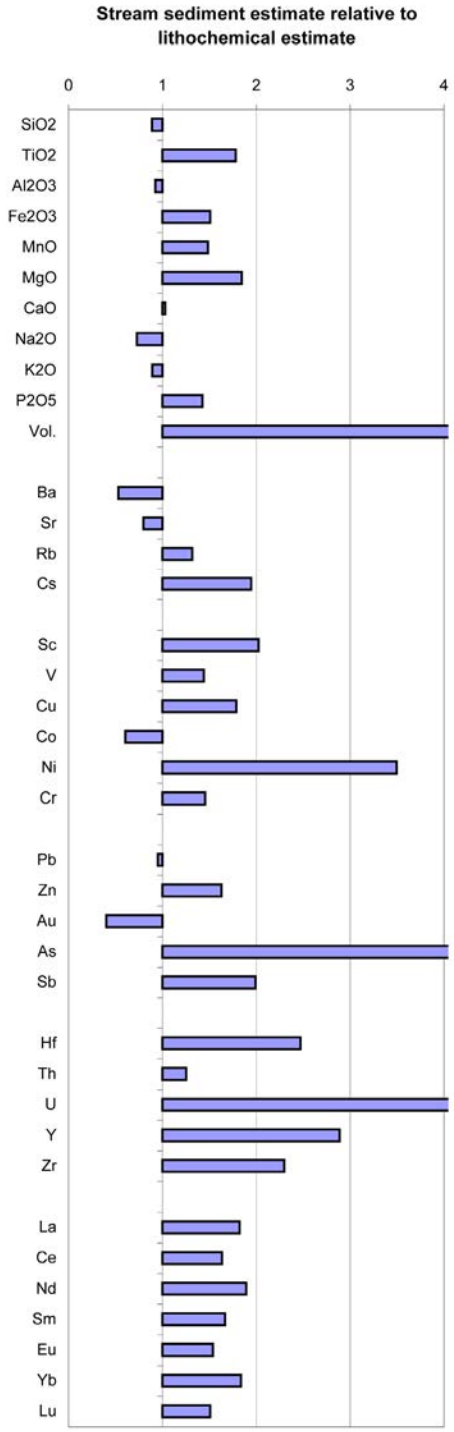


Figure 7. *Diagram showing the ratio between element concentrations estimated by stream sediment data and those estimated by lithochemical data. Vol. = volatiles.*

It is observed that element concentrations in the stream sediment estimate are generally higher than the lithochemical estimate, although it is only for Ni, As, Hf, U, Zr and Y that the values are more than twice as high. Nine elements have lower concentrations in the stream sediment estimate than in the lithochemical estimate (Si, Al, Na, K, Ba, Sr, Co, Pb, Au).

There are two main reasons for the differences. One is that the stream sediment estimates record the total rock assemblage of the drainage areas, thus including components such as minor rock units, alteration and mineralisation that are not accounted for in the calculation of the lithochemical composition.

The other reason is that the loose material developing on the surface of solid rocks as a result of weathering undergoes compositional changes during erosion and transport in the stream environment. Thus, the fine fraction of stream sediment is not identical to the unweathered rock material. Where the bedrock consists of gneiss, granite and crystalline schists, the most important processes are removal of feldspar components and mica (muscovite, biotite, sericite etc.), preferential enrichment of small refractory minerals (zircon, sphene, monazite, spinel etc.), and exclusion of quartz grains.

A detailed interpretation of the differences is not possible nor is it the objective of the present project. However, it is felt reasonable to regard the relative enrichment in “mafic” elements (Fe, Mg, Ti, Mn, Sc to Cr) in stream sediment as an expression of a higher proportion of mafic rocks than accounted for in the lithochemical estimate. Relatively high As and U in stream sediment is probably a reflection of mineralisation. The high Ni and Y in stream sediment is probably due to an underestimation of the Ni-concentration in the granodiorite (code 420, see Table A1), because of the high detection limit in XRF analysis (Table 2). The relatively high Hf to Zr and REE, plus the reduced element concentrations in stream sediment are seen as effects of compositional changes in the stream environment. The high Au in rocks relative to stream sediment is due to bias, as only two samples of granodiorite were analysed for Au, one having a gold concentration of 22 ppb, the other 1 ppb (Table A1). The median of 11.5 ppb Au is far too high as a representative value.

For the present purpose it is significant to notice that both ways of calculation reach similar results for most elements, and the background concentrations of elements for the three selected land areas of the study region are considered to be within the limits given in Table 10.

The data for the individual drainage areas (Table A2) exhibit the same kind of differences between stream sediment and lithological estimates as those for the main areas.

Difference between areas

Main areas

Table 10 and Figure 8 compare the data obtained for the three main areas. In Figure 8, the stream sediment data are normalised against the total stream sediment average, whereas the lithochemical data are normalised against the lithochemical average for the total area (Table 10).

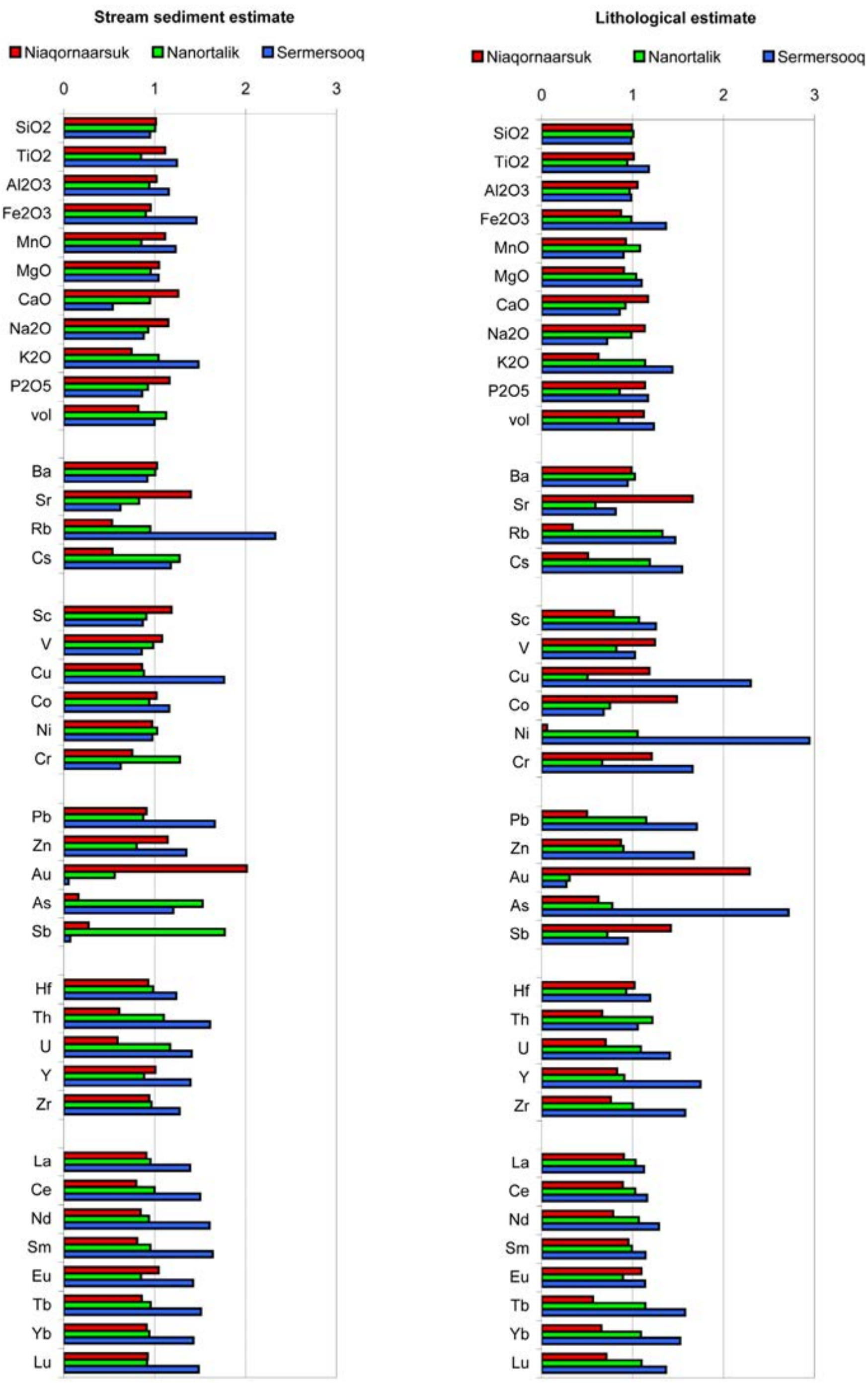


Figure 8. *Differences in estimated element concentrations between main areas. Left diagram shows stream sediment medians for an area ratioed against stream sediment medians for the entire study area, the right diagram shows lithochemically estimated concentrations ratioed against estimated concentrations for the entire study area. vol = volatiles.*

The effect of preferential enrichment or depletion in the stream environment is counteracted when the stream sediment chemical and lithochemical data are normalised against average values derived from the same kind of data.

The differences between the areas are reflected similarly in the two diagrams in Figure 8, and they can be related to varying proportions of the lithologies present (see Figure 6 and Table 7). In summary, Niaqornaarsuk is dioritic (high Ca, Na, Sr) with indication of gold and minor zinc mineralisation, Nanortalik is dominated by granitic compositions (high K, Rb,Cs) with indication of As-Sb mineralisation, and the Sermersooq composition reflects the influence of metapelite giving elevated Cu,Pb,Zn,As and the high proportion of rapakivi granite providing high Hf-Zr and REE. Late granites give high Rb and Cs in Sermersooq. The Ni and Au data in the lithochemical estimate are not reliable.

Individual drainage areas

Figs 9 and 10 contain diagrammatic presentations of the total-composition-normalised element values for each drainage area in the two large peninsulas, stream sediment based and lithology based, respectively. Table 4 and 9 contain the data. The data for Sermersooq are represented in Figure 8.

Niaqornaarsuk peninsula (Figure 9)

The main lithology is the granodiorite to diorite of the Julianehåb batholith, and therefore, the lithochemical estimates for the five drainage areas are very similar. The stream sediment data display a greater variation and clearly reflect the amount of mafic dykes and mineralisation affecting drainage areas 2, 3 and 4. Area 1 appears the most “clean” granodiorite area and the stream sediment estimate is close to the lithology-based estimate when they are normalised.

Nanortalik peninsula (Figure 10)

The drainage areas vary more in the Nanortalik peninsula because of the fairly large difference between the chemistries of mafic volcanic rocks on the one hand, and late granites and psammites on the other. The Fe_2O_3, MgO, Sc and Co patterns show this most clearly in both estimates. The stream sediment estimates also display great variation in elements of mineralisation (Au, As, Sb) and in those contained in late granites and rapakivi granites (Hf-Zr and REE). Area 14, in particular, is anomalous in these elements showing that rapakivi granite has intruded this area and suggesting the presence of gold mineralisation. The geological map at 1:100 000 scale (Allaart 1973) shows rapakivi granite in area 14, but it has been omitted in the simplified digital version at 1:500 000 used here. It must be remembered, though, that the stream sediment medians for area 14 concerning elements determined by INA is only based on three samples (see Table 4) and they are hardly representative for the entire area 14.

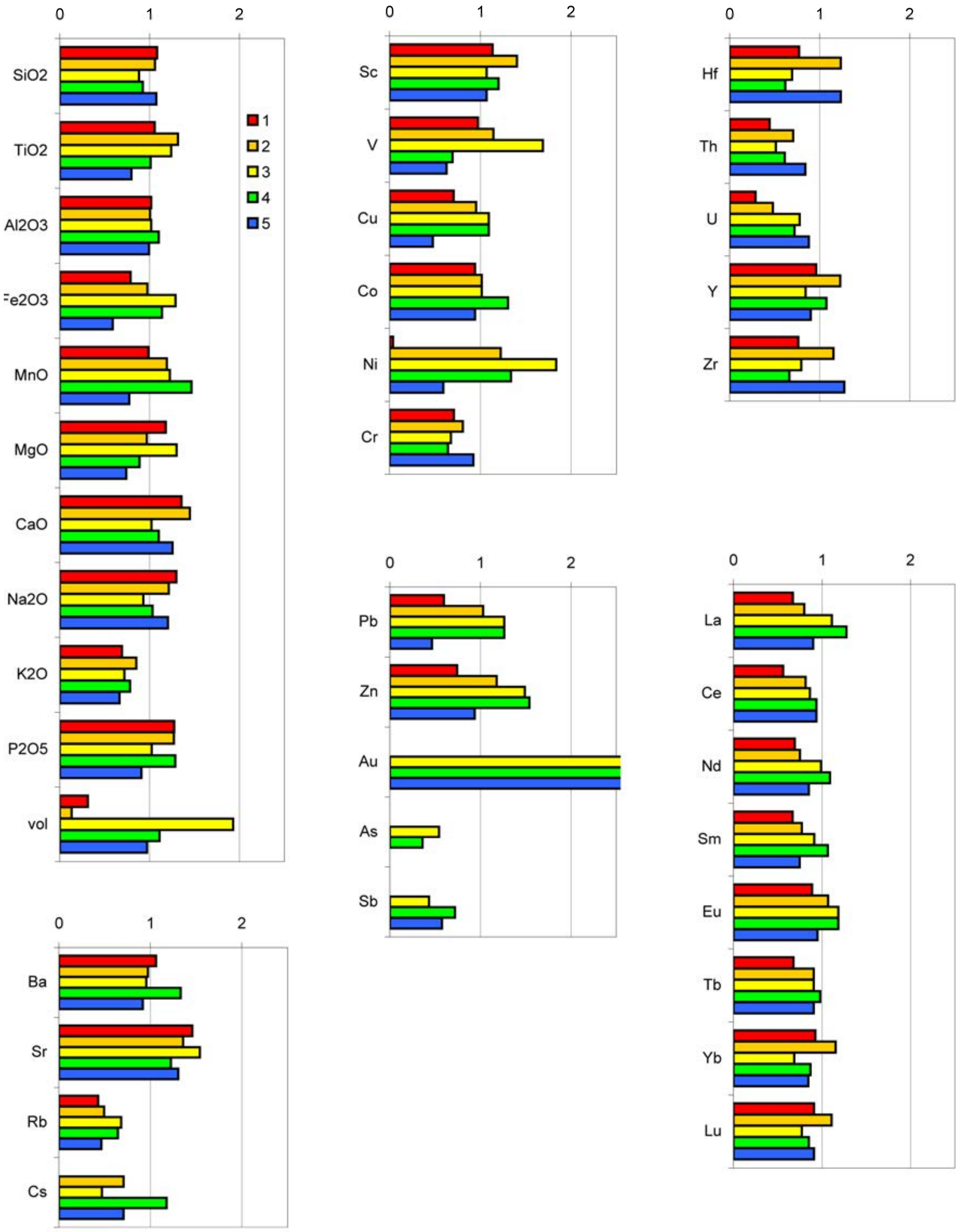


Figure 9a. *Diagrammatic illustration of differences in median element concentrations based on* ***stream sediment data*** *between drainage areas within the* ***Niaqornaarsuk peninsula****. The area medians are ratioed against the estimated stream sediment concentrations for the entire study area.*

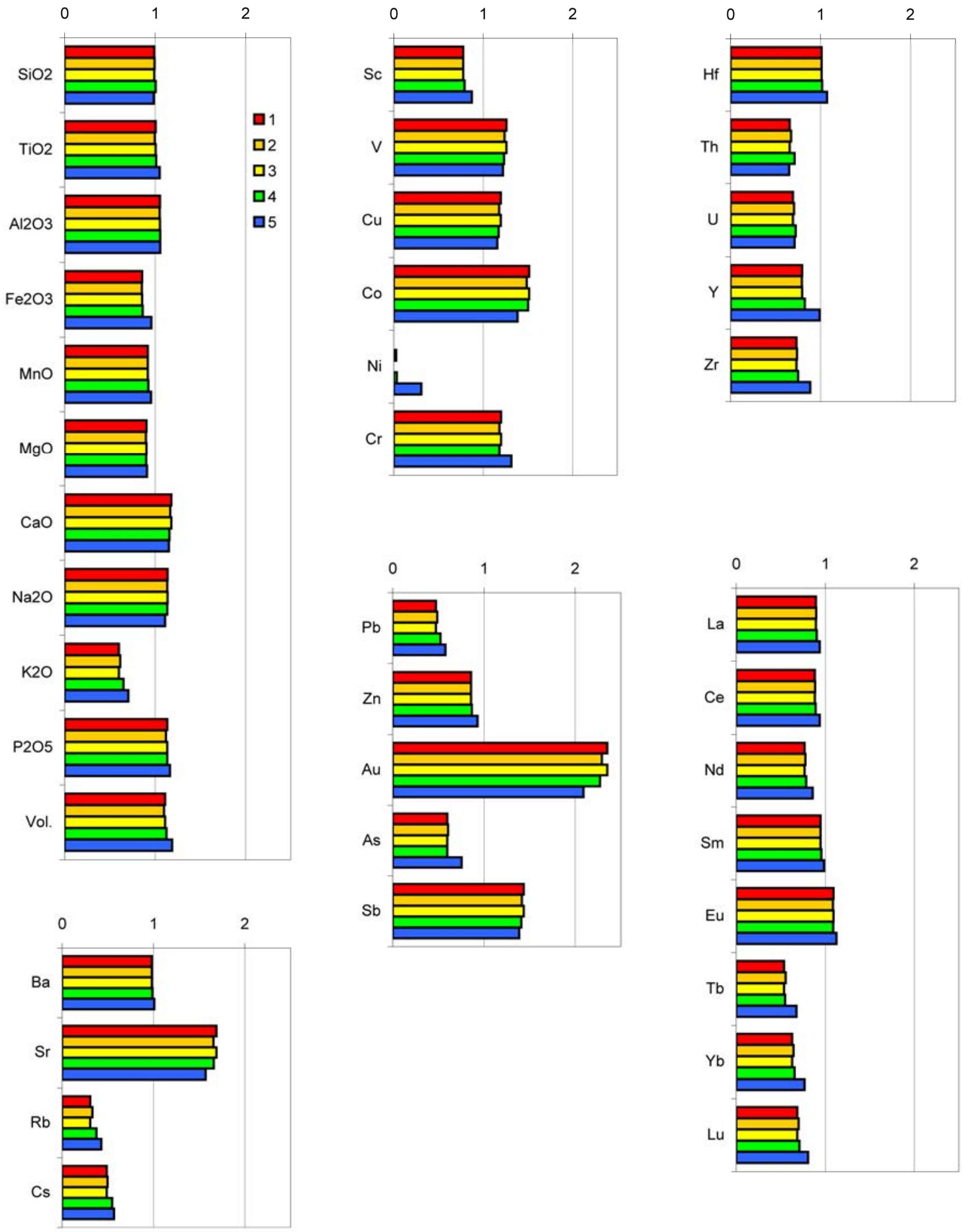


Figure 9b. *Diagrammatic illustration of differences in element concentrations based on* ***lithochemical data*** *between drainage areas in the* ***Niaqornaarsuk peninsula****. The data are ratioed against the estimated concentrations for the entire study area.*

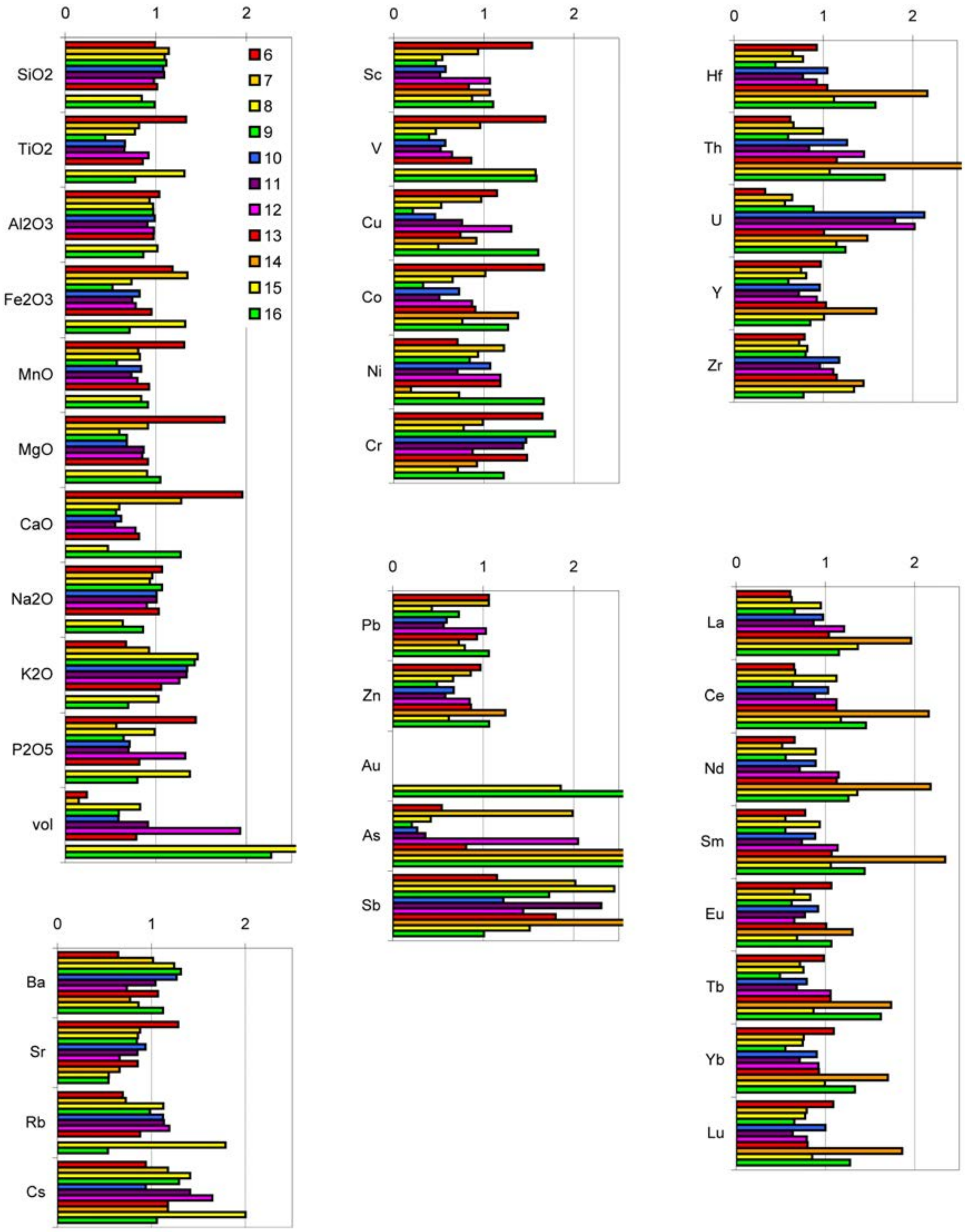


Figure 10a. *Diagrammatic illustration of differences in median element concentrations based on* ***stream sediment data*** *between drainage areas within the* ***Nanortalik peninsula****. The medians are ratioed against the estimated concentrations for the entire area.*

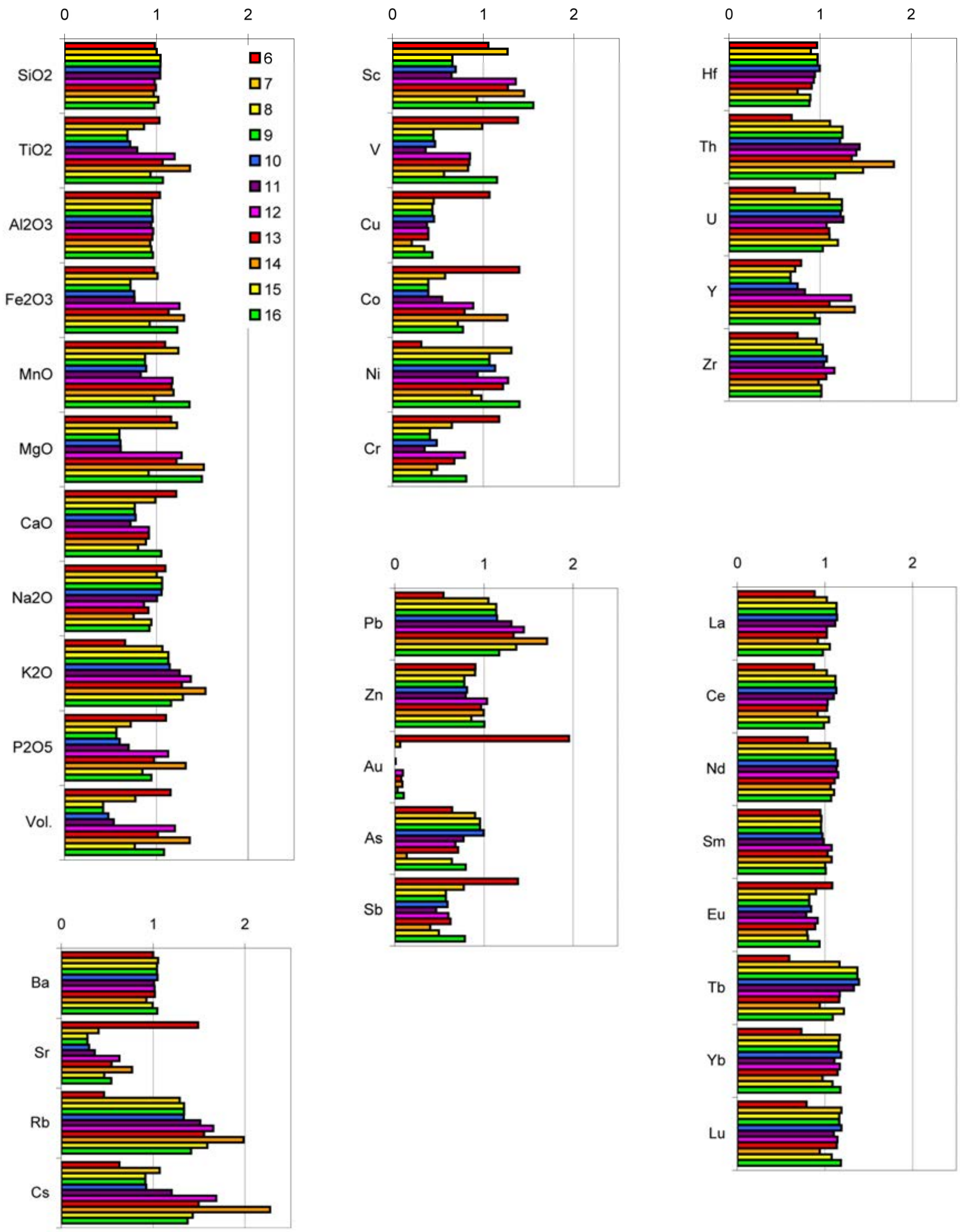


Figure 10b. *Diagrammatic illustration of differences in element concentrations based on* ***lithochemical data*** *between drainage areas in the* ***Nanortalik peninsula****. The data are ratioed against the estimated concentrations for the entire area.*

Influence of mineral occurrences and mineralisation

Several of the drainage areas contain known mineral occurrences and samples of stream sediment, heavy mineral concentrates and rock samples with unusually high concentrations of one and more elements reveal that alteration and mineralisation has taken place at additional sites. However, the anomalous samples are generally single samples within a drainage area so that it may be assumed that the mineralised sites have limited extent. Tables 11 to 13 contain the maximum concentrations obtained in each drainage area, and they illustrate the magnitude of the local enrichments. Table 14 contains a summary of anomalies registered within each drainage area.

The influence of mineralisation is seen to some extent in the stream sediment medians used to construct the diagrams (Figures 8 to 10), but the influence is naturally greater on the stream sediment means (Table 5).

Downstream dispersion of ore material

Another way of investigating the influence of mineral occurrences on the composition of the stream material is to compare data from upstream samples having anomalously high metal content with those of samples taken further downstream. Such kind of investigations has not been carried out in this area, and the stream sediment sampling is generally constrained to first order streams. However, a few places have been found within the study area, where a sample have been collected in a higher order stream near the coast and where elevated metal contents have been obtained upstream in the same catchment area. The available data for the comparisons of metal concentrations in the upper and lower part of a stream system are listed in Table 15, and the stream systems showing sample location are given in Figure 11.

The anomalously high concentrations in the upstream samples together with the corresponding values in the downstream sample are marked in bold figures in Table 15. With very few exceptions a considerable decrease in concentrations from upper to lower sample is observed. This illustrates the limited effect of local metal concentrations (small mineral occurrences) on the composition of the material that enters the fjord at the outlet of the stream. The reason for this is probably the dilution of the anomalous stream material with material derived from non-mineralised rock assemblages. It would need a dedicated new sampling and analytical program to document the dispersion ranges for various types of mineral occurrences in relation to morphology, hydrology and other stream properties, but the data presented here give an indication of some general trends.

Stream sediment, maximum concentrations

Drainage		1	2	3	4	5	17
XRF							
SiO_2	%	67.5	67.6	57.0	65.5	64.4	60.7
TiO_2	%	1.2	1.4	**1.9**	1.2	0.7	1.3
Al_2O_3	%	15.4	15.0	17.2	16.3	14.3	16.7
Fe_2O_3	%	7.0	7.3	12.8	11.6	3.8	12.5
MnO	%	0.12	0.12	**0.24**	0.18	0.07	0
MgO	%	2.8	2.8	5.5	4.7	1.5	2
CaO	%	5.7	5.2	4.2	4.9	4.2	2
Na_2O	%	3.8	4.0	3.0	3.6	3.4	3
K_2O	%	3.3	2.6	2.9	3.1	1.8	5
P_2O_5	%	0.37	0.45	0.59	0.46	0.21	0
Vol.	%	4.4	4.4	11.4	16.3	5.1	6
Cr	ppm	24	57	97	76	8	49
Cu	ppm	37	27	67	59	11	59
Ni	ppm	70	28	46	43	21	42
Rb	ppm	96	120	143	144	52	356
Sr	ppm	479	441	351	427	394	155
V	ppm	101	109	151	140	44	69
Zn	ppm	**235**	116	**285**	**211**	56	**334**
Zr	ppm	793	**1128**	404		570	
INA							
As	ppm	5	44	12	52	7	**150**
Au	ppb	**210**	30	33	**169**	**620**	17
Ba	ppm	760	690	720	920	520	670
Co	ppm	35	29	28	25	20	35
Cr	ppm	**300**	96	120	110	63	77
Cs	ppm	2	7	10	8	4	12
Hf	ppm	21	**43**	12	14	25	89
Mo	ppm	7	7	0	6	12	0
Rb	ppm	94	130	130	160	100	**290**
Sb	ppm	1	1	0	1	0	1
Sc	ppm	21	25	22	23	23	28
Ta	ppm	2	3	1	1	1	4
Th	ppm	11	17	12	18	16	**74**
U	ppm	**110**	93	44	**210**	15	100
Zn	ppm	160	180	150	210	150	200
La	ppm	120	110	96	130	55	**220**
Ce	ppm	140	190	130	160	100	**360**
Nd	ppm	87	95	70	110	52	180
Sm	ppm	12	15	12	18	7	36
Eu	ppm	3	5	3	5	3	4
Tb	ppm	2	2	2	2	2	6
Yb	ppm	5	7	4	3	6	**14**
Lu	ppm	1	1	1	1	1	2
Risø XRF							
Cr	ppm	270	161	**421**	161	46	223
Cu	ppm	37	72	85	78	34	88
Fe_2O_3	%	11.6	15.4	19.1	17.7	8.8	20.6
Ga	ppm	22	27	30	30	19	52
K_2O	%	2.95	2.28	2.26	2.90	2.73	4.41
MnO	%	0.15	0.16	**0.27**	**0.21**	0.14	0.22
Nb	ppm	21	50	37	32	29	**70**
Ni	ppm	77	65	89	82	34	73
Pb	ppm	26	36	33	35	18	**70**
Rb	ppm	132	164	207	254	164	**530**
Sr	ppm	572	557	584	458	460	334
TiO_2	%	1.13	**1.88**	**1.77**	1.10	1.27	**2.27**
U	ppm	**142**	**114**	41	**184**	42.9	113
Y	ppm	57	97	56	55	62	**186**
Zn	ppm	206	173	**313**	**387**	120	**318**
Zr	ppm	681	**1396**	451	**1179**	957	**2718**

Table 11a. *Maximum concentrations determined in stream sediment samples from drainage areas within Niaqornaarsuk peninsula and Sermersooq. The highest values are marked in bold digits.*

Stream sediment maximum concentrations

Drainage		6	7	8	9	10	11	12	13	14	15	16
XRF												
SiO_2	%	62.3	72.0	68.4	73.7	69.0	69.8	65.9	69.1		50.6	59.1
TiO_2	%	1.2	0.8	0.8	0.6	0.8	0.6	0.9	1.1		1.1	0.6
Al_2O_3	%	15.8	13.7	14.3	14.2	19.0	14.3	15.5	15.2		14.7	12.5
Fe_2O_3	%	9.6	11.6	5.7	6.0	6.3	5.6	7.1	9.8		8.6	4.6
MnO	%	0.15	0.12	0.09	0.07	0.13	0.07	0.12	0.13		0.08	0
MgO	%	4.4	2.0	1.4	2.9	2.7	3.4	2.3	4.2		1.9	2
CaO	%	8.1	7.7	2.2	2.4	2.9	2.2	4.5	8.3		1.6	4
Na_2O	%	3.4	3.6	2.7	3.1	3.1	3.0	2.9	3.3		1.8	2
K_2O	%	2.5	3.5	4.4	4.2	4.1	3.8	3.7	4.1		2.8	2
P_2O_5	%	0.45	0.14	0.32	0.19	0.25	0.29	0.38	0.28		0.31	0
Vol.	%	9.0	1.4	5.8	3.1	9.3	10.1	29.8	9.7		16.0	12
Cr	ppm	115	127	46	190	95	**369**	114	178		117	128
Cu	ppm	50	31	33	22	28	44	65	**110**		34	28
Ni	ppm	53	42	28	56	37	76	42	96		38	38
Rb	ppm	117	91	130	118	204	141	173	163		202	61
Sr	ppm	400	361	292	287	329	264	305	262		247	269
V	ppm	157	117	42	45	46	45	93	189		110	111
Zn	ppm	113	83	97	39	131	57	**179**	110		**190**	86
Zr	ppm	995					310	531				
INA												
As	ppm	**78**	**340**	27	6	**140**	35	**110**	29	**1100**	**120**	**130**
Au	ppb	**270**	77	8	0	20	25	25	**180**	30	13	25
Ba	ppm	780	820	840	880	**1700**	770	730	840	570	710	730
Co	ppm	28	50	10	21	15	16	27	29	21	15	35
Cr	ppm	140	**360**	180	**530**	120	**350**	150	190	73	70	120
Cs	ppm	14	7	9	**18**	**17**	9	**18**	**19**	8	**16**	7
Hf	ppm	25	18	13	31	30	17	37	31	33	31	38
Mo	ppm	6	12	0	0	0	0	0	0	0	0	0
Rb	ppm	110	96	110	140	160	130	160	130	120	140	100
Sb	ppm	1	2	2	2	1	2	3	4	**14**	2	1
Sc	ppm	27	36	11	11	12	10	25	29	21	20	24
Ta	ppm	2	2	1	1	2	2	2	3	2	1	3
Th	ppm	17	12	17	26	26	24	**52**	26	51	21	34
U	ppm	10	**120**	25	49	**310**	160	**410**	46	**240**	66	110
Zn	ppm	160	210	67	66	87	60	190	130	390	140	210
La	ppm	66	59	72	93	**490**	75	130	100	**230**	110	140
Ce	ppm	120	140	140	160	**590**	160	**320**	160	**240**	150	**310**
Nd	ppm	56	46	52	60	370	67	110	97	190	110	130
Sm	ppm	9	10	9	10	57	11	19	15	28	12	21
Eu	ppm	2	2	2	2	4	2	3	2	3	2	3
Tb	ppm	2	2	2	2	5	2	3	2	4	2	3
Yb	ppm	5	4	3	4	6	4	6	5	7	5	8
Lu	ppm	1	1	1	0	4	1	1	1	1	1	1
Risø XRF												
Cr	ppm	181	**425**	84	**587**	31	165	133	198	0	24	245
Cu	ppm	65	97	22	37	82	34	**182**	104	97	31	**144**
Fe_2O_3	%	11.6	12.3	5.7	8.5	6.2	7.4	5.6	12.9	9.4	10.1	13.6
Ga	ppm	21	17	17	18	19	18	15.494	23	21	23	25
K_2O	%	2.54	4.06	4.13	4.14	3.61	3.96	3.91	3.52	2.93	2.96	2.93
MnO	%	0.14	0.14	0.08	0.11	0.09	0.08	0.16	0.12	0.10	0.08	0.17
Nb	ppm	33	27	26	27	28	38	45	33	41	42	39
Ni	ppm	49	78	39	**159**	57	86	109	96	43	34	117
Pb	ppm	37	23	12	36	22	16	30	29	24	26	32
Rb	ppm	163	188	222	**292**	**273**	241	**322**	258	194	**284**	225
Sr	ppm	475	350	299	337	343	300	506	317	227	283	517
TiO_2	%	1.33	1.08	0.90	1.10	0.95	1.02	1.12	1.10	1.37	1.17	1.03
U	ppm	13.4	**125**	24.9	68	**255**	156	**459**	39.8	76.3	68.9	**284**
Y	ppm	70	48	41	45	75	72	90	80	83	97	90
Zn	ppm	116	**284**	112	113	130	110	206	125	**404**	147	**276**
Zr	ppm	1069	611	421	734	971	683	**1174**	998	1015	**1980**	1168

Table 11b. *Maximum concentrations determined in stream sediment samples from drainage areas within Nanortalik peninsula. Anomalous values are marked in bold digits.*

Rock maximum concentrations

	Niaqornaarsuk				Nanortalik						
Area	**1**	**2**	**3**	**4**	**6**	**7**	**9**	**10**	**11**	**12**	**13**
No samples	*10*	*32*	*91*	*108*	*17*	*17*	*1*	*5*	*3*	*20*	*3*
No XRF	*0*	*13*	*16*	*23*	*1*	*0*	*0*	*4*	*3*	*4*	*3*
SiO_2		75.25	83.32	77.88	70.36			71.16	68.92	74.00	70.60
TiO_2		1.23	1.88	2.71	0.51			0.39	0.77	0.59	0.64
Al_2O_3		20.11	18.96	19.89	14.27			16.78	14.48	19.84	14.65
FeO		9.84	8.57	10.35	3.30			0.00	3.84	0.12	2.63
Fe_2O_3		2.71	2.80	3.25	0.55			3.41	0.91	8.33	0.65
MnO		0.25	0.17	0.26	0.04			0.06	0.06	0.47	0.04
MgO		9.77	5.91	9.69	1.48			1.38	1.23	0.95	0.75
CaO		10.10	8.64	9.24	1.49			3.31	2.29	17.50	1.70
Na_2O		4.84	7.21	5.33	2.80			4.66	3.01	3.18	3.19
K_2O		4.88	5.07	6.56	3.54			4.71	4.83	6.77	6.05
P_2O_5		0.35	0.96	1.11	0.16			0.15	0.26	0.18	0.22
vol		6.55	2.41	3.52	1.03			1.26	1.34	1.55	0.73
Ba		**5629**	1800	1709	759			1309	916	839	965
Cr		167	160	397	87			0	30	126	16
Cu		**4890**	56	**1193**	20			0	0	68	0
Ni		96	21	245	5			0	13	25	6
Rb		154	134	215	126			163	201	266	214
Sr		667	865	532	158			1695	337	1721	269
V		246	260	197	67			0	35	222	21
Zn		198	97	215	84			0	96	43	84
Zr		588	354	307	227			254	241	205	414
No ICP	*10*	*31*	*78*	*103*	*8*	*12*	*1*	*0*	*0*	*3*	*0*
TiO_2	1.2	1.1	4.7	2.3	1.2	0.8	0.1			0.0	
Al_2O_3	15.7	21.0	18.0	19.7	14.6	14.6	12.2			0.0	
Fe_2O_3_ina	8.1	15.6	18.4	**25.3**	**30.7**	17.2	2.7			**49.8**	
MnO	0.10	0.21	0.23	0.89	0.14	0.18	0.04			0.00	
MgO	2.8	11.1	17.8	11.1	8.0	9.5	0.5			0.0	
CaO	5.0	17.2	33.0	13.6	18.2	14.0	2.2			30.8	
Na_2O_ina	5.1	6.4	6.7	6.8	5.6	7.5	3.0			0.0	
K_2O	2.6	6.4	5.0	10.7	5.2	6.3	2.0			0.0	
P_2O_5	0.6	0.3	0.9	1.0	0.4	0.4	0.1			0.0	
Ag	1	4	**572**	5	2	4	0	1		0	
Be	5	4	5	24	43	142	2	0		0	
Bi	0	0	**1613**	33	0	248	0	0		0	
Cd	1	1	1	21	0	4	0	1		-1	
Cu	**320**	**4241**	**1107**	**1135**	**1132**	**1058**	8	26		2	
Ni	25	90	276	204	**559**	75	13	235		3	
Pb	17	57	**6784**	**390**	45	**474**	16	98		86	
Sr	587	905	1011	1370	637	538	188	0		0	
V	106	189	**343**	285	146	227	12	0		0	
Y	74	47	38	61	23	16	8	21		101	
Zn_icp/ina	88	170	**383**	**3134**	**726**	**630**	40	75		**2580**	
No INA	*10*	*32*	*86*	*104*	*16*	*17*	*1*	*5*		*20*	
As	3	10	**4400**	54	**56**	**250**	4	3		**220**	
Au (ppb)	**732**	**825**	**220000**	**21300**	40	**385**	0	1		75	
Ba	1200	6200	2700	2200	1200	910	750	-1		300	
Co	28	44	78	50	320	67	4	63		64	
Cr	1	190	700	**1400**	**1200**	**1800**	39	563		230	
Cs	8	3	7	12	7	56	3	8		21	
Hf	5	16	18	14	8	7	5	6		6	
Mo	**94**	4	**983**	11	20	19	2	0		3	
Rb	1	180	190	340	180	500	78	149		258	
Sb	18	1	2	2	3	2	2	1		15	
Sc	1	44	52	49	41	42	4	26		46	
Se	26	0	6	0	3	9	0	0		8	
Ta	2	2	3	15	25	**65**	1	2		2	
Th	**54**	17	32	28	19	14	12	16		32	
U	**110**	6	12	12	19	39	3	**251**		47	
La	10	**81**	**87**	**93**	25	47	40	60		61	
Ce	3	**160**	**150**	**140**	52	90	73	118		132	
Nd	3	**63**	**59**	**49**	27	33	26	42		51	
Sm	7	13	11	9	5	7	4	7		8	
Eu	0.9	2.7	5.9	4.7	1.7	1.8	0.8	1.3		0.9	
Tb		2.1	1.6	1.8	0.7	1.2	0.0	0.5		1.9	
Yb		6.4	5.3	7.2	5.1	5.9	1.9	2.3		8.4	
Lu		1.0	0.8	1.2	0.9	0.9	0.3	0.3		1.4	

Table 12. *Maximum concentrations determined in rock samples from drainage areas within Niaqornaarsuk and Nanortalik peninsulas. Anomalous values are marked in bold digits. Oxides in %, trace elements in ppm except Au. No = Number of analysed samples. Analytical methods, see Table 2.*

Heavy mineral concentrate retrieved from stream sediment samples

Niaqornaarsuk peninsula

Drainage		1			2			3			4			5		
No		*31*			*23*			*29*			*27*			*9*		
		Max.	Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.
As	INA	9	1	0.0	**200**	29	9.0	46	6.3	3.0	**180**	18	10.0	**570**	70	6.0
Au ppb	INA	**3570**	145	0.0	**6570**	697	26.0	**1350**	139	26	**5400**	631	50	**2080**	413	0.0
Ba	INA	790	301	350	710	63	0	600	276	330	810	55	0	440	49	0
Co	INA	300	44	34	74	42	39	66	23	21	94	52	58	57	31	29
Cr	INA	**83000**	2813	130	**740**	200	170	220	98	92	580	118	99	280	146	130
Cu	AAS	**720**	47	25	117	31	26	46	23	22	83	24	22	78	40	32
Hf	INA	95	36	29	110	40	32	55	20	18	**500**	67	27	**220**	69	57
Pb	AAS	**63**	9	6	**325**	23	0	17	7.5	7	14	6	4	15	6.8	6
Sb	INA	1.1	0.2	0.0	1.3	0.3	8.0	0.9	0.3	0.0	2	0.4	0.0	0.7	0.3	0.0
Sc	INA	9	4	4.0	8	3.4	3.0	9	4.8	5.0	9	4.4	4.0	9	5.6	5.0
Ta	INA	7	1.6	1.0	**46**	9.8	8.0	13	1.9	1.0	**43**	8.7	6.0	20	10.3	11.0
Th	INA	36	14	9.5	26	11.4	11.0	12	5.6	5.2	55	10.7	7.3	21	13.2	12.0
U	INA	24	8	7.2	14	7.2	6.8	9.1	4.5	4.1	40	8.9	6.8	21	11.0	8.9
W	INA	190	33	18	**300**	83	30	160	26	17	**5400**	343	70	**1000**	306	130
Zn	INA	**2600**	106	0	**420**	108	0	240	31	0	**470**	193	230	300	33	0

Nanortalik peninsula

Drainage		6			7			8			9			10			11		
No		*57*			*57*			*13*			*24*			*28*			*6*		
		Max.	Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.	Max.	Mean	Med.
As	INA	**390**	61	26	**1500**	105	18.0	**230**	28	5.0	25	4	5.0	49	8	6.0	5	2	1.5
Au ppb	INA	**1070**	88	0	**326**	27	0.0	28	2	0.0	64	5	0.0	61	8	0.0	22	4	0.0
Ba	INA	630	96	0	850	123	0	970	128	0	520	88	0	870	179	0	330	55	0
Co	INA	85	34	34	160	38	30	51	21	18	41	20	19	52	22	21	25	18	19
Cr	INA	**1300**	286	240	**890**	289	220	550	300	310	**840**	464	450	**980**	466	485	460	261	250
Cu	AAS	90	33	27	154	17	12	52	29	26	201	47	35	68	24	20	36	26	25
Hf	INA	**570**	59	21	91	25	24	88	36	29	52	24	24	**270**	53	30	31	19	21
Pb	AAS	**83**	8.8	6.0	24	7.7	6.0	11	5.1	5.0	30	7.1	4.0	10	4.0	3.5	8	4.5	5.0
Sb	INA	5	1.4	1.1	**9.9**	2.9	1.6	**9.9**	5.0	4.1	**9.7**	4.5	4.6	**9.2**	3.7	3.0	**7.1**	3.2	2.0
Sc	INA	9	4	4.0	9	5	5.0	8	4	4.0	9	4	4.0	9	5.5	6.5	8	5.3	5.0
Ta	INA	**49**	7.2	3.0	23	7.1	6.0	19	9.0	8.0	23	9.5	10.0	23	9.3	9.0	17	9.8	11.0
Th	INA	52	13	9.7	**71**	11	11.0	**70**	24	22.0	49	28	30.5	**83**	34.9	38.0	32	22.5	26.5
U	INA	**55**	9	5.9	26	8	8.6	**51**	23	18.0	30	19	19.0	**55**	19.2	18.0	21	15.1	18.5
W	INA	**1300**	136	44	**3200**	164	33	200	56	41	190	43	34	250	58	44	18	7.3	7.0
Zn	INA	330	53	0	**5300**	219	0	200	15	0	0	0	0	340	49	0	0	0.0	0

Table 13. *Maximum concentrations determined in samples of heavy mineral concentrate from stream sediment. Anomalous values are marked in bold digits. Elements concentrations in ppm, except Au. No = Number of analysed samples. Max.= maximum. Med. = median. Analytical methods, see Table 2.*

Niaqornaarsuk	**1**	**2**	**3**	**4**	**5**
Mineral occurrences		Au	Au	Au	
Rock maxima	Au,Cu,Mo,Th,U	Ba,Cu,Au	Ag,Bi,Cu,Pb,V, Zn,As,Au,Mo	Cu,Fe,Pb,Zn,Au,Cr	No data
Stream sediment maxima	Zn,Au,Cr,U	Zr,Hf,W,Ti	Cr,Ti,Zn	Zn, Au, U	Au
HMC maxima	Au,Cr,Cu,Pb,Zn	Au,As,Pb,W	Au	Au,As,Hf,Ta,W,Zn	Au,As,Hf ,W

Nanortalik	**6**	**7**	**8**	**9**	**10**	**11**
Mineral occurrences		Au,Cu-Zn, PGE				PGE
Rock maxima	Cu,Ni,Zn,As,Cr	Cu,Ni,Pb,As,Au, Cr,Ta	No data	None	U	No data
Stream sediment maxima	As,Au	As,Cr,U,Zn	None	Cr,Cs,Ni,Rb	As,Cs,R b,U, La,Ce	Cr
HMC maxima	Au,As,Cr,Pb,Ta, W	As,W	As,Sb,Th,U	Cr,Sb	Cr,Hf,Sb, Th,U	Sb

	12	**13**	**14**	**15**	**16**
Mineral occurrences	Au				Au
Rock maxima	Fe,Zn,As	No data	No data	No data	No data
Stream sediment maxima	Cu,Rb,U	Zn,As,Cs,Ni,Th, U,Ce	Fe,As,Sb,U,Zn, La,Ce	As,Rb,Zn,Zr	As,Cu,U, Zn,Ce
HMC maxima	No data	No data	No data	No data	No data

Sermersooq	**17**
Mineral occurrences	
Rock maxima	No data
Stream sediment maxima	Zn,As,Nb,Pb,Rb, Th,U,La,Ce,Yb, Y,Zn,Zr
HMC maxima	No data

Table 14. *Summary of anomalous element concentrations recorded in individual drainage areas.*

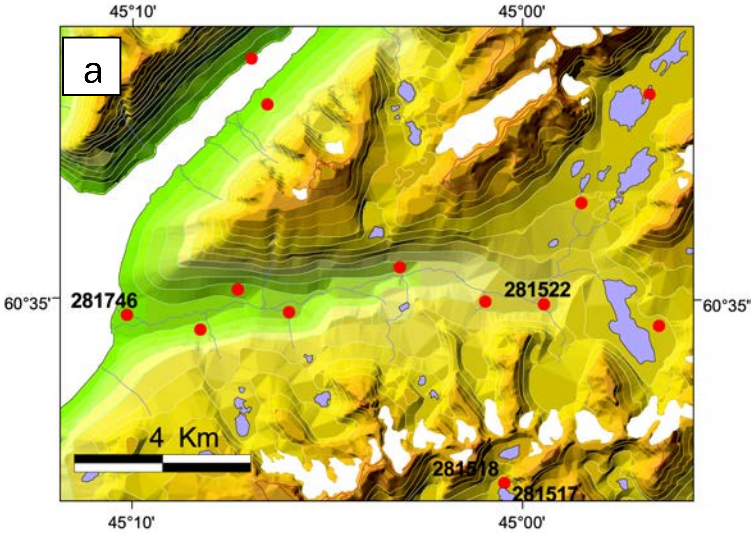
	Upper	*Coast*		Upper	*Coast*		Upper	*Coast*
Distance	10.2 km			14.4 km			11.5 km	
Sample ID	281522	*281746*		281517	*281748*		281555	*281744*
Drainage	3	*3*		4	*4*		1	*1*
Longitude	-44.99	*-45.169*		-45.002	*-45.235*		-44.946	*-45.073*
Latitude	60.583	*60.5804*		60.5397	*60.53*		60.7291	*60.6512*
Altitude m	500	*26*		800	*0*		363	*54*
RisøXRF								
TiO_2	**1.07**	***0.58***		0.75	*1.10*		**0.95**	***0.67***
Fe_2O_3	**15.76**	***4.79***		9.32	*6.16*		8.38	*4.80*
MnO	**0.20**	***0.06***		**0.15**	***0.09***		0.09	*0.06*
CaO	4.49	*3.71*		3.74	*4.67*		4.60	*4.37*
K_2O	1.98	*1.36*		1.18	*1.49*		1.53	*1.60*
Cr	**137**	***0***		0	*0*		0	*0*
Cu	**81**	***5***		**76**	***8***		**27**	***15***
Ga	27	*15*		18	*21*		20	*16*
Nb	19	*16*		12	*24*		10	*14*
Ni	**89**	***34***		22	*35*		8	*38*
Pb	**33**	*5*		12	*12*		9	*4*
Rb	128	*36*		120	*55*		54	*57*
Sr	422	*476*		332	*458*		536	*536*
U	27.6	*12.6*		**79.7**	***5.08***		3.33	*2.56*
Y	38	*32*		53	*55*		32	*41*
Zn	**313**	***49***		**387**	***70***		**88**	***57***
Zr	215	*451*		183	*1179*		205	*378*
INA								
As	9	6						
Au ppb	33	6						
Ba	530	580						
Co	22	9						
Cr	57	41						
Cs	7	0						
Hf	5	12						
Rb	96	0						
Sb	0.3	0.3						
Sc	22	13						
Ta	0	0						
Th	12	3.3						
U	28	8.9						
La	75	25						
Ce	100	46						
Nd	50	22						
Sm	8.7	3.8						
Eu	2	1.1						
Tb	1.4	1.3						
Yb	2.25	2.62						
Lu	0.49	0.37						

Table 15a. *Element concentrations in upstream and downstream samples from three drainage areas in Niaqornaarsuk peninsula (Figure 11a to c). Oxides in %, trace elements in ppm except Au. Pronounced downstream dilution marked in bold digits.*

	Upper	Upper	Upper	Upper	*Coast*
Distance	5.1 km	5.1 km	4.3 km	4.3 km	
grl_nr	281929	281930	281931	281932	*280610*
catchment					
longitude	-44.538	-44.54	-44.55	-44.558	*-44.6*
latitude	60.3505	60.348	60.356	60.3541	*60.377*
altitude m	311	300	313	306	*24*
RisøXRF					
TiO_2	1.35	1.57	1.52	1.35	*1.03*
Fe_2O_3	6.42	8.21	9.32	8.72	*5.96*
MnO	0.08	0.11	0.12	0.10	*0.08*
CaO	3.06	4.44	4.06	3.51	*3.92*
K_2O	3.18	2.26	3.24	2.93	*2.70*
Cr	16	**115**	0	0	***0***
Cu	28	23	**46**	**41**	***10***
Ga	23	19	30	24	*17*
Nb	42	25	**78**	**69**	***21***
Ni	18	19	33	18	*6*
Pb	26	14	29	24	*7*
Rb	134	86	206	250	*96*
Sr	389	400	198	163	*405*
U	17.9	8.05	**26.6**	**34.6**	***6.52***
Y	111	65	**206**	**173**	***50***
Zn	77	98	**164**	**147**	***75***
Zr	**1944**	**824**	**3156**	**1785**	***674***
GEUSXRF					
SiO_2	***64.858***	***63.708***			***66.4***
TiO_2	1.412	1.252			*0.72*
Al_2O_3	14.516	13.558			*14.38*
Fe_2O_3	6.348	7.387			*5.27*
MnO	0.132	0.148			*0.09*
MgO	1.706	2.651			*2.01*
CaO	3.196	4.561			*3.88*
Na_2O	3.25	3.24			*3.35*
K_2O	3.30	2.39			*2.94*
P_2O_5	0.51	0.60			*0.50*
vol	0.35	0.04			*0.21*
Cr	**100**	**157**			***42***
Cu	18	21			*15*
Ni	34	30			*21*
Rb	70	42			*65*
Sr	432	445			*371*
V	65	110			*43*
zn	119	126			*57*
INA					
As	5	8	**16**	**26**	***6***
Au ppb	**80**	0	0	0	*0*
Ba	590	730	710	700	*700*
Co	7	11	10	13	*8*
Cr	39	77	26	0	*61*
Cs	2	0	5	9	*0*
Hf	58	20	**110**	**69**	***13***
Rb	100	58	110	150	*43*
Sb	0	0.7	1.4	2	*0.5*
Sc	17	19	24	23	*14*
Th	**110**	20	42	**68**	***16***
U	12	5.4	20	29	*6.6*
La	210	53	100	140	*55*
Ce	**380**	97	**250**	**310**	***110***
Nd	130	48	110	140	*50*
Sm	24	8.3	23	26	*9.3*
Eu	1.4	1.3	2.6	4.4	*1.5*
Tb	2.2	1.4	3.7	3.8	*1.1*
Yb	7.06	4.37	**15.3**	**14.9**	***2.92***
Lu	0.93	0.56	1.83	1.97	*0.37*

	Upper	Upper	Upper	*Coast*
Distance	3.9 km	3.9 km	2.9 km	
grl_nr	281925	281926	281928	*280611*
catchment				
longitude	-44.5332	-44.5317	-44.5523	*-44.6005*
latitude	60.39528	60.393	60.39231	*60.3923*
altitude m	300	300	200	*14*
RisøXRF				
TiO_2	1.85	1.48	1.82	*1.72*
Fe_2O_3	16.21	7.94	10.24	*7.29*
MnO	0.17	0.09	0.12	*0.09*
CaO	4.38	4.28	5.22	*4.46*
K_2O	2.61	3.11	3.04	*2.85*
Cr	0	0	72	*0*
Cu	**89**	20	**53**	***23***
Ga	52	26	29	*26*
Nb	65	61	96	*70*
Ni	**65**	25	**47**	***23***
Pb	**53**	22	**43**	***20***
Rb	175	156	175	*141*
Sr	167	214	222	*214*
U	**33.2**	11.7	22.9	***13.1***
Y	203	148	304	*175*
Zn	208	115	152	*112*
Zr	3931	1438	4753	*2524*

Table 15b. *Element concentrations in upstream and downstream samples from two drainage areas east of Nanortalik peninsula (Figure 11d). Oxides in %, trace elements in ppm except Au. Pronounced downstreams dilution marked in bold digits.*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60°35'
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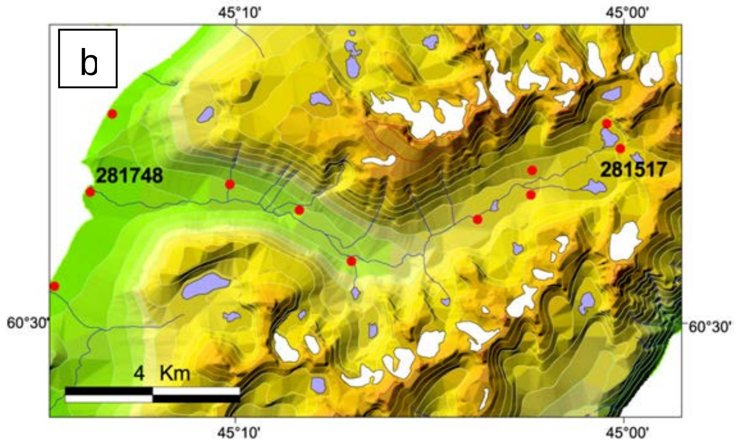
4 Km
281518
281517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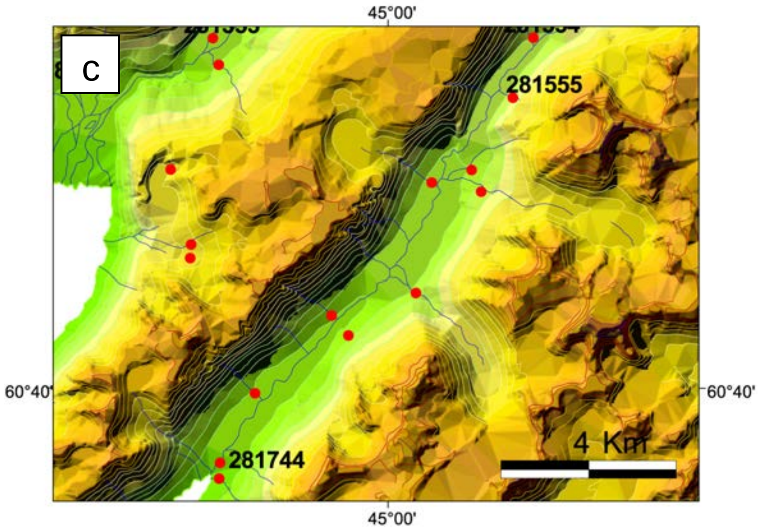
281517
60°30'
4 Km


c
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281555
60°40'
281744
4 Km

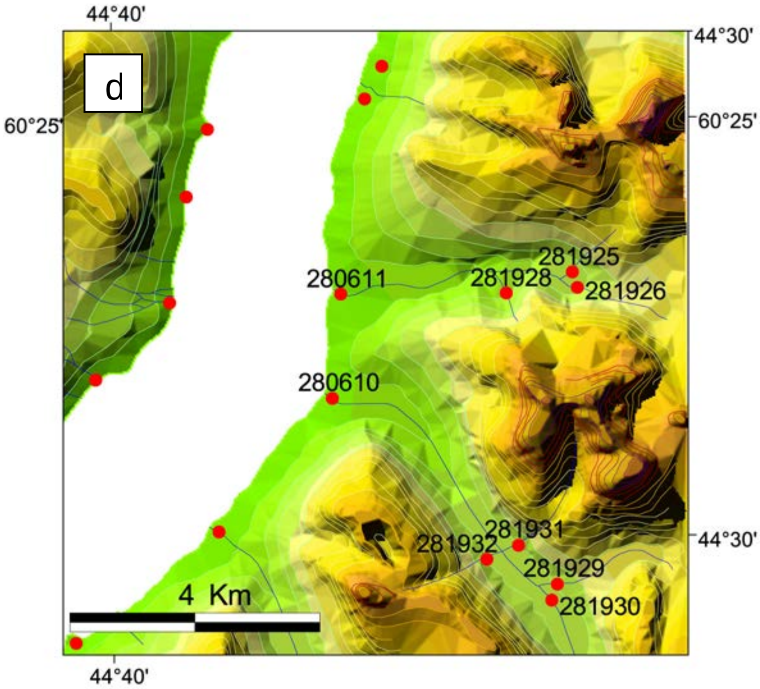

Figure 11. *Close-up of drainage areas and position of samples illustrating downstream dispersion of metals documented in Table 15. The close-ups represent drainage areas 3 (a), 4 (b), 1 (c) and an area on the eastern side of Tasermiut Kangerluat (Figure 1) opposite the boundary between areas 10 and 13 (Figure 4).*

Use of digital terrain model to calculate drainage basin volumes

The ArcView/ArcGIS software by Environmental Systems Research Institute (ESRI) offers the possibility of calculating the volume of drainage basin, provided these can be derived from the digital terrain model. However, our test revealed that the model available for South Greenland does not have sufficient resolution to meet the requirements for such calculation. Nonetheless, the methodology appears promising and could be a valuable component in future assessments. The present project did not allow the time for the production of a better digital terrain model.

Discussion

Validity of estimates

Ideally, stream sediment estimates should have been based on regularly distributed samples that were all analysed for the same (long) suite of elements. The lithochemical data should have been based on an adequate number of consistent analytical data from representative samples of all mapped lithological units. Unfortunately, as explained in the section on available data, data for concentrations of trace elements determined by INA are not available for all stream sediment samples and major element data are even fewer. Likewise, the data for rock chemistry could have been more comprehensive. Although more data would undoubtedly improve the estimated chemical compositions, particularly of individual drainage areas, the estimated compositions for the three main areas, Niaqornaarsuq peninsula, Nanortalik peninsula and Sermersooq island are reasonably well founded. Uncertainties are most pronounced in the estimation of element concentrations that are close to the lower limit of detection for the analytical method.

Neither of the methods provides a fully reliable chemical composition. The stream sediment data based on fine grain size fractions are depleted in SiO_2 and other elements (e.g. Ba and Sr), and enriched in a number of trace elements relative to their concentration in the source rock, as explained in the section on difference between methods. However, within terrains of similar lithology, the kind and magnitude of such depletions and enrichments are relatively consistent, so that the data can be adjusted. The stream sediment data have the advantage that they pick up the chemical signal from unmapped rock units, chemically diverse rocks, alteration and mineralisation. The rock data, on the other hand, provide a more precise estimate of the composition of the most common rock types, but they do not include unknown units. Therefore, the acquisition of both data sets gives a more complete basis for estimating the composition of an area, because the true composition probably lies within the limits of the two data sets. Considering the uncertainties in both data sets, it has not been found justified to present an estimate combining the data. It must be kept in mind that each of the element concentrations presented in Table 10 represents a statistically calculated estimate expressing that the correct value probably lies within a range of values around the estimate. The traditionally used statistical parameter, the standard deviation, is not presented here, because many of the element data do not comply with such well-defined populations that the standard deviation is meant to describe.

Local background variation

The study region contains an assemblage of chemically diverse rock units and several types of mineralisation, and that causes considerable compositional variation among the individual drainage areas, see Figures 9 and 10. This is an important observation for evaluations of the impact of non-natural activities on the local environment. Any impact should be measured against the local background and evaluated in view of the natural variation documented by available data, such as those presented here. Elements of environmental concern commonly comprise the trace elements Pb, Ni, Cr, As, Sb, U, and it is valuable to observe that large parts of the study region are naturally enriched in As, Sb and U, and that Pb and Cr enrichments occur locally. In this context it is also interesting to notice that the stream sediment data presented here are derived from samples collected in 1979, long before activities in connection with gold exploitation at Nalunaq and elsewhere were initiated.

Gold potential of the study region

The gold potential of the study region has been recognised since the beginning of the 1990's (Steenfelt 1990; Steenfelt & Tukiainen 1991) and has been confirmed most convincingly by the opening of the Nalunaq gold mine. As a side effect of the present study, the data presented is a reminder that high gold concentrations occur in stream sediment from several other sites, also outside the known gold mineralisations (Figure 12).

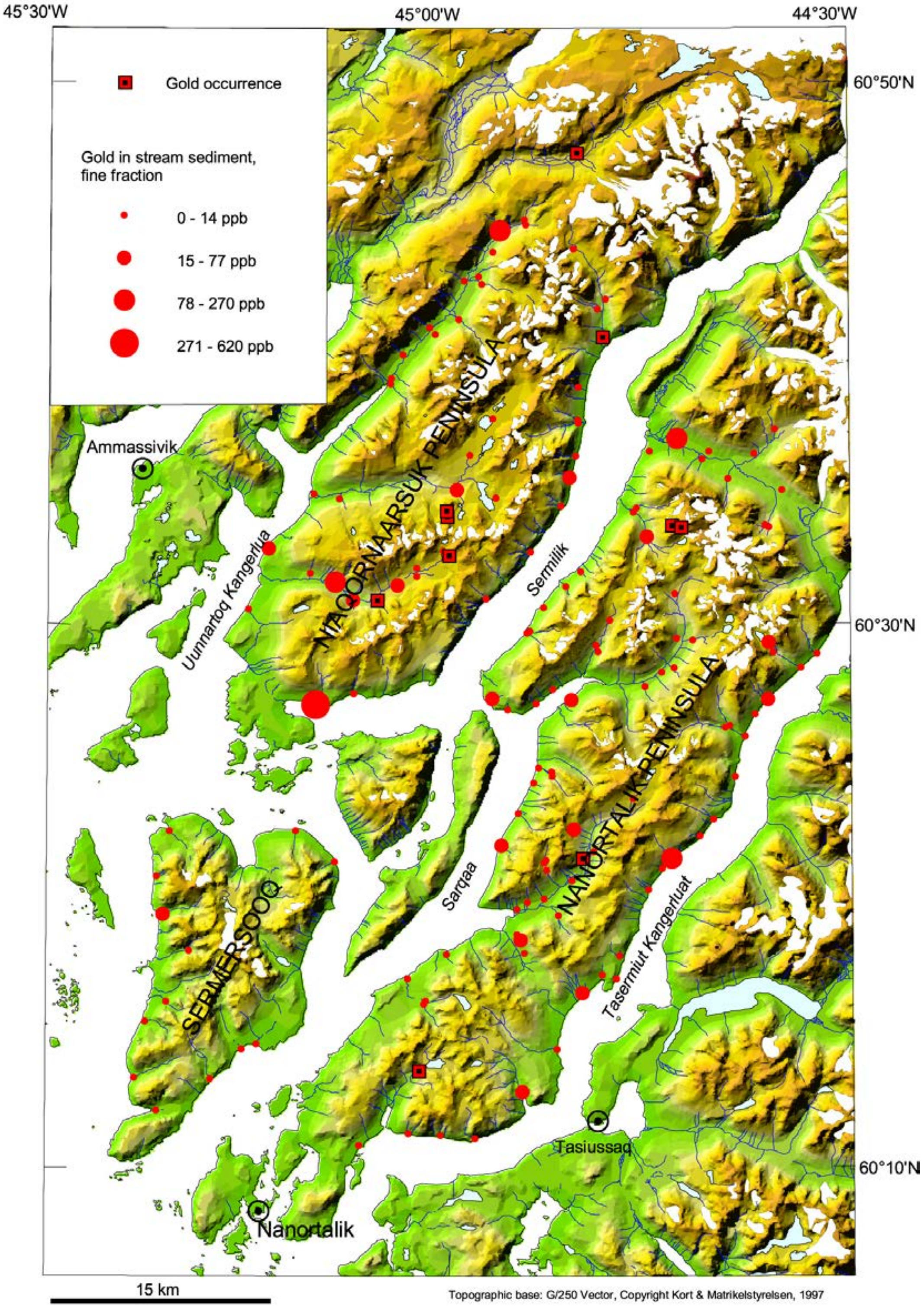

Figure 12. *Gold concentrations determined in the < 0.1 mm grain size fraction of stream sediment.*

Implications for compositions of fjord sediments

All along steep coasts, loose material produced by weathering of bedrock is shed more or less directly into the fjords. Inland, the loose material gradually develops into soil (commonly vegetated), where it is not immediately transported downwards in drainage systems. Over time though, even the soil gets eroded and transported into the fjords or the sea. The mechanical and chemical processes acting on the material during erosion and transport may create temporal differences, whereby resistant minerals tend to be upgraded on land while clay and mica are preferentially carried to the sea by fast flowing water. Ultimately however, all material, apart from the negligible amount dissolved by stream- or sea-water, gets deposited on the bottom of the fjords.

The bulk composition of the fjord sediment must be largely the same as the bulk composition of the large rock mass that has contributed material to the fjord during and after the last glaciation, except for minor dissolved components. However, the sedimentary pile deposited at the bottom is stratified and the upper strata that sustain present day flora and fauna can be assumed to represent material deposited since the termination of the last glaciation. There is no doubt that the active glaciers are the main contributors of material to the presently deposited fjord sediments. This material is derived from the rock complexes behind the head of the fjords. The material derived from the drainage areas of the study region will probably only dominate shallow environments immediately surrounding the outlets of the major streams, where the chemical composition will roughly correspond to that of the presently exposed rock complexes.

It should be remembered that the stream sediment estimate is biased, as it is based on the composition of the fine grain size fraction (< 0.1 mm) only. The material carried to the fjord contains more coarse material, relatively rich in quartz and therefore less concentrated in other components, as well as more clay and mica that have been carried in suspension by the stream water. The latter counteracts the dilution effect of the quartz, so that the chemical composition of the fine fraction of stream sediment is less far from the actual composition of the material entering the fjords. However, the topography of the fjord bottom must be known in order to predict where material discharged from glaciers and streams gets deposited. It is likely that the finest particles are kept in suspension even in the seawater and are, therefore, not deposited in the fjords at all.

Although it is believed that the bulk of the fjord sediment reflects the chemistry of the bedrock including alteration and mineralisation in adjacent land areas, the complex interactions of water currents imply that it is not straightforward to predict the chemical composition of a sediment at a specific site in the fjord.

Marine terraces

South Greenland has undergone considerable postglacial uplift as witnessed by marine terraces flanking main valley sides at altitudes up to 60 m above sea level. The terraces represent material deposited in a marine environment in minor arms of the former fjord systems. Thus, they can be regarded as former counterparts of present-day near-coastal fjord sediments. A comparison between the chemistry of the terrace material with the estimates presented in this report of the locally derived drainage material, could indicate to what extent the local material is reflected in the fjord sediments.

Comparison of the study region with the average composition for Greenland

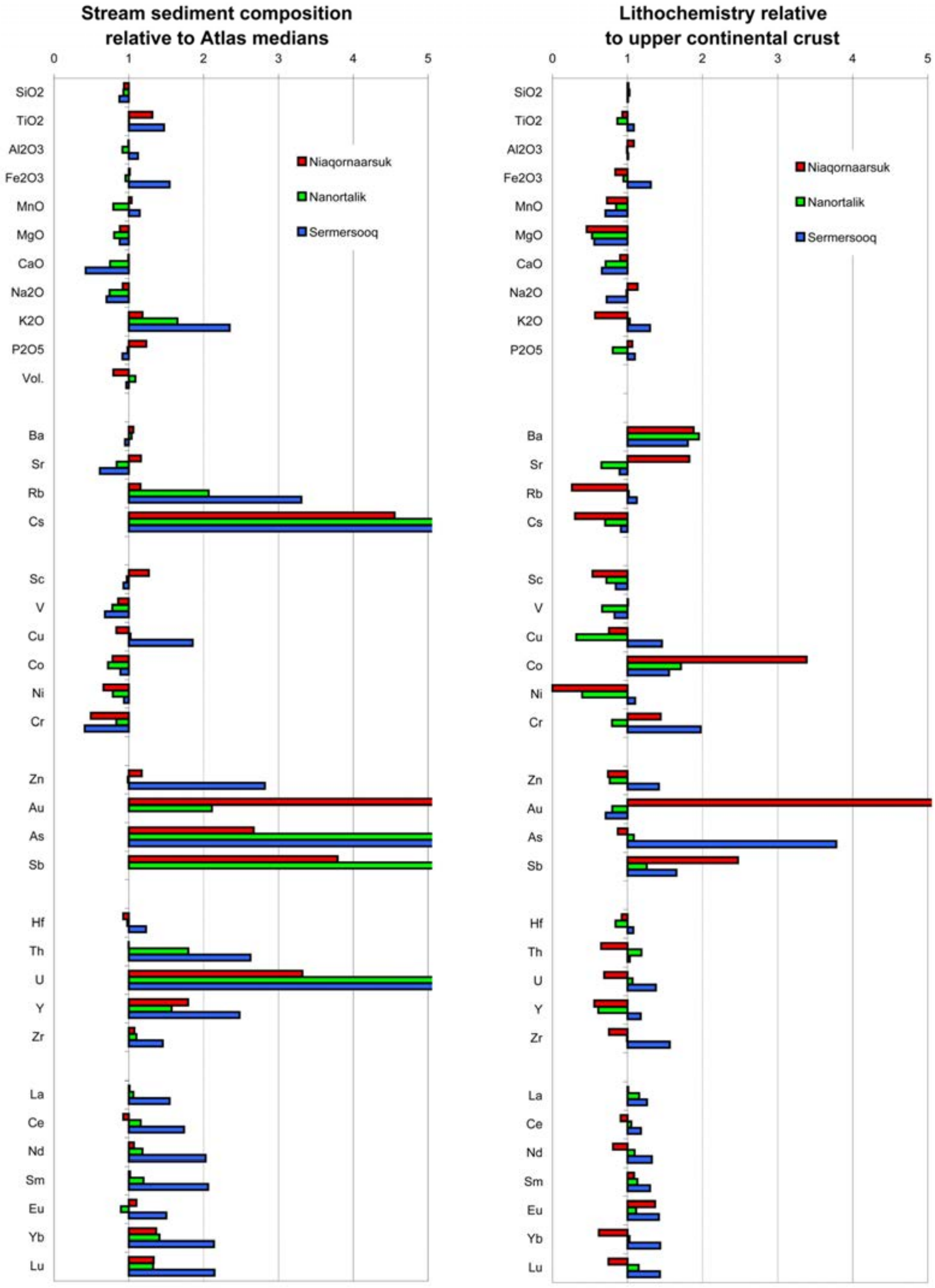

Figure 13. *Estimated concentrations for the three main areas in South Greenland compared to other data. The stream sediment data are ratioed against medians of data for the rest of West and South Greenland (Steenfelt 2001), and the lithochemical data (Vol.-free) are ratioed against estimated data for the upper continental crust (Taylor & McLennan 1985).*

The geochemical atlas contains an average composition for West and South Greenland based on median element concentrations of stream sediment samples. It may be useful to realise how the chemical composition of the study regions compares with the rest of Greenland and the world. In the diagram of Figure 13, the stream sediment medians for the main areas are normalised against the atlas medians and the lithologically estimated concentrations are normalised against a compositional estimate for the Earth's upper continental crust.

The diagrams illustrate that the study region in South Greenland is naturally enriched in lithophile elements (K, Rb, Cs) and elements associated with gold mineralisation (Au, As, Sb). In addition, Sermersooq is enriched in Hf, Zr, REE, Y. The strong enrichment in U relative to the rest of Greenland expressed by stream sediment data from the study region is not obvious in the lithological data. According to previous publications (Armour-Brown *et al.* 1983) there are two reasons for this. One is that U mineralisation is hosted by fractures, and therefore do not affect the chemistry of the rock samples that is the basis of the lithological estimate. The other is that U-rich components tend to get fixed by organic matter in the stream sediment. Likewise, Au, As and Sb are hosted by fracture and alteration zones, so that they make a greater impact on the stream sediment than the rock chemical composition. The overestimated Au concentration of the granodiorite of Niaqornaarsuk Peninsula has been commented in an earlier section.

The natural enrichment features specific to the study region are important to take into account in any assessment of chemical impact caused by non-natural activity.

Suggestions for sampling and analysis to improve estimates

Increasing and improving the data base

The kind of estimates presented in this report would gain in reliability if the available data could be supplemented with more samples and more chemical analyses, particularly in those drainage areas where the present data are statistically insufficient to justify the calculation of means and medians. In addition, presently available and new samples should be analysed by methods providing lower limits of detection. Rock samples should be collected more systematically within all mapped lithological units. All such rock samples should be analysed by quality controlled methods to provide a consistent data set.

Establishing compositional relationships between rock units and sediment deposited in streams draining that particular rock unit

New rock sampling should ensure that samples are collected close to streams with known sediment chemistry, so that the relation between rock chemistry and corresponding stream sediment chemistry can be established. Such sampling should be conducted in widely different rock types. When the chemical relationships between rock and derived stream sediment have been established for the common rock types in Greenland, the stream sediment data alone may be used to estimate compositions of other areas where rock data are scarce or absent.

Estimation of changes over time
Resampling and analysis of sediment from a number of selected streams would provide information on any change in chemical composition of stream sediment since 1979. The number of resampled streams should be statistically significant to define a possible change.

Baseline data for major streams
The stream sediment sampling undertaken in the Syduran project was largely constrained to first and second order streams. For the purpose of estimating the composition of larger areas and monitoring the flow of material entering the fjords, it would be desirable to acquire baseline data for the large streams close to their outlets into the fjords or sea. As many of the large streams are braided, the sampling should ensure that the full width is represented. In addition, sampling should be undertaken three or four times over the year, because the chemical composition of material deposited exhibits seasonal changes. Determination of the load of transported material should be part of the baseline data in order to enable the estimation of the amount of erosion as well as of the amount of metals entering the marine environment. The mineral content and chemistry of different grain size fractions should be determined to establish the relationship between mineral behaviour and chemical composition.

Conclusion

Available data in GEUS' databases have provided an adequate basis for an estimation of the chemical composition of given areas in South Greenland. It was found important to use two methods of calculating the chemistry, because either method has shortcomings. The estimate based on the fine fraction of stream sediment is biased because of mineral differentiation during erosion and transport, and the estimate based on lithological data is biased because it does not include influence from unmapped rock units and mineralisation. Together, the two estimates probably frame the 'true' composition.

The density of available samples or available analytical data is not high enough to provide statistically significant chemical compositions for small areas, and new samples and chemical analyses of these are necessary to improve the reliability of estimated compositions.

The difference in chemistry between local drainage areas and between the larger areas, Niaqornaarsuk and Nanortalik peninsulas and Sermersooq, emphasises the significance of using the local geochemical background as a basis for evaluating a natural or non-natural change in the surface environment.

As a supplement to the available data, it is suggested to acquire chemical data for sediment deposited at the outlets of major streams and to measure the sediment load.

Compared to the remaining Greenland and the upper continental crust in general, the study region is considerably enriched in gold (Au), arsenic (As), antimony (Sb) and uranium (U), in addition to potassium (K_2O), rubidium (Rb) and caesium (Cs). Mineralised sites appear to be small and metal-enriched stream sediment encountered close to a mineralisation undergoes downstream dilution.

Acknowledgment

Research Establishment Risø analysed all stream sediment samples during the Syduran project (1979-1982). Nunaoil A/S financed INA analysis of Syduran stream sediment samples (1990) and gave permission to use their heavy mineral data in the resource evaluation project for South Greenland carried out by GEUS 1997-2000.

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Appendix

The appendix contains two tables:

Table A1 contains full analytical documentation of rock samples used to estimate representative chemical compositions for common rock types in the study area.

Table A2 contains the two different estimates made for each drainage area and the averages for the main areas.

grl_nr	Description	SiO_2	TiO_2	Al_2O_3	FeO	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Vol.	Ba	Cr	Cu	Ni	Rb	Sr	V	Zn	Zr	TiO_2	Al_2O_3	Fe_2O_3	MgO	MnO	CaO	Na_2O	K_2O	P_2O_5	*SUM*
		%	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	%	%	%	%	%	%	*%*
		XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF		XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	XRF	ICP	ICP	INA	ICP	ICP	INA	INA	ICP	ICP	
405234	Julianehab batholith	72,14	0,25	14,48	1,60	0,80	0,04	0,70	2,81	4,11	2,17	0,14	0,58	1311	52	8	< dl	15	570	51	35	138										
154030	granodiorite	70,8	0,16	16,56	1,31	0,12	0,04	0,18	2,94	5,51	1,76	0,05	0,32																			
404504	Julianehab batholith	70,80	0,46	14,20	1,80	1,20	0,05	0,66	2,15	3,10	4,58	0,14	0,90	1700	< dl	< dl	< dl	97	420	40	42	220										
404954	Julianehab batholith	70,10	0,34	15,04	1,33	1,06	0,06	0,80	2,83	4,46	2,83	0,18	0,45	1371	52	15	< dl	14	739	56	41	62										
404902	Julianehab batholith	69,16	0,35	15,54	1,25	1,11	0,03	0,70	2,34	3,88	4,59	0,14	0,62	3216	46	20	< dl	46	843	73	27	123										
404517	Julianehab batholith	67,90	0,36	16,60	2,30	0,60	0,05	1,00	4,12	4,40	1,58	0,16	0,90	800	< dl	38	< dl	37	650	24	42	180	1,37	13,30	6,83	3,78	0,12	4,95	6,65	1,52	0,28	*38,80*
404514	Magmatic_Plut Medium Felsic	67,66	0,36	16,53	2,17	0,77	0,05	1,01	4,03	4,69	1,57	0,18	0,54	1029	54	14	2	13	593	47	42	160										
412976	granite	65,81	0,55	16,00	3,52	0,50	0,08	1,97	4,29	4,44	1,37	0,18	0,84	834	< dl	18	< dl	26	532	66	80	151	0,50	15,13	4,90	1,91	0,07	4,02	4,14	1,14	0,15	*31,96*
405233	Julianehab batholith	65,60	0,47	16,39	2,29	1,75	0,06	0,89	3,03	4,64	3,47	0,17	0,54	1273	49	24	< dl	65	444	49	52	283										
404936	Julianehab batholith	65,57	0,47	16,15	2,94	1,48	0,08	1,72	4,47	4,43	1,36	0,21	0,66	881	43	29	40	14	696	92	61	100										
404507	Julianehab batholith	64,90	0,53	16,60	2,40	1,30	0,06	1,67	4,21	4,50	1,93	0,23	1,50	1000	14	16	< dl	33	1100	61	61	66										
404508	Magmatic_Plut Medium Interm	63,97	0,63	16,55	3,10	1,41	0,07	1,64	3,58	4,97	3,12	0,26	0,66	969	58	22	3	75	476	73	64	208										
405217	Magmatic_Plut Felsic Heterog	61,81	0,66	17,33	2,79	1,91	0,07	2,06	5,09	4,80	1,60	0,34	0,98	1046	50	29	< dl	8	1163	91	77	94										
404925	Julianehab batholith	59,01	0,75	17,63	4,26	1,47	0,10	3,21	6,60	3,73	1,31	0,30	1,00	705	62	12	2	14	865	108	97	120										
Median		66,74	0,46	16,46	2,30	1,15	0,06	1,01	3,81	4,45	1,85	0,18	0,66	1029	51	19	< dl	26	650	61	52	138	0,93	14,22	5,87	2,84	0,10	4,48	5,39	1,33	0,21	35,38
Number		*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*14*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*13*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*	*2*
411690	Magmatic Medium Mafic	53,83	1,13	16,02	8,46	1,06	0,13	4,76	7,44	4,96	0,44	0,25	1,1	115	79	64	11	29	614	233	64	106	0,95	12,60	11,25	4,23	0,11	6,27	4,88	0,33	0,20	*40,82*
403974	Volc_Sed Magmatic_Extr Mafic																								12,20			9,79				
413067	rusty amphibolite																						0,75	14,04	11,52	7,69	0,18	4,80	3,26	0,69	0,14	*43,07*
413070	rusty amphibolite																						0,63	12,98	8,95	5,29	0,13	8,59	3,64	1,16	0,12	*41,50*
412975	amphibolite	50,39	2,71	13,95	10,35	3,25	0,26	3,84	7,34	3,04	1,87	1,11	1,76	1201	0	20	0	78	410	191	104	143	2,30	13,43	16,87	4,03	0,22	6,49	3,28	1,60	0,97	*49,20*
411673	Unknown Heterog Mafic	50,24	0,71	14,69	9,84	2,71	0,25	6,07	8,20	2,49	2,80	0,17	1,72	1358	88	8	20	87	214	191	198	101	0,58	11,90	15,58	5,57	0,21	6,72	2,25	2,43	0,13	*45,38*
411674	Unknown Heterog Mafic	51,48	0,82	15,70	8,83	1,78	0,21	5,48	7,57	2,15	3,20	0,27	1,64	1861	106	9	26	95	257	204	180	103	0,70	12,36	13,33	5,11	0,18	6,45	2,56	2,70	0,21	*43,60*
411675	Magmatic_Plut Heterog Felsic	51,30	0,86	15,51	8,82	1,94	0,20	5,89	9,11	2,67	1,49	0,25	1,55	302	117	9	23	59	438	246	158	105	0,73	10,54	13,15	5,34	0,18	7,63	2,68	1,11	0,20	*41,56*
Median		51,30	0,86	15,51	8,83	1,94	0,21	5,48	7,57	2,67	1,87	0,25	1,64	1201	88	9	20	78	410	204	158	105	0,73	12,60	12,67	5,29	0,18	6,60	3,26	1,16	0,20	43,07
Number		*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*7*	*7*	*8*	*7*	*7*	*8*	*7*	*7*	*7*	*7*
289494	rapakivi, dark	67,25	0,58	15,86		5,52	0,06	2,34	1,47	1,75	3,38	0,10	1,56	937	133	16	29	80	185	94	84	249										
289504	rapakivi	62,37	0,68	17,24		6,23	0,08	0,34	4,07	3,41	4,82	0,26	0,18	1920	36,2	14	4	118	396	13	157	685										
289511	rapakivi, light,typical	67,29	0,73	14,35		6,23	0,06	0,90	2,06	3,36	4,60	0,26	0,68	657	70,3	16	16	159	166	23	105	485										
289516	rapakivi	61,77	0,70	17,47		5,36	0,07	1,65	3,81	3,52	4,76	0,23	0,71	1702	207	13	26	112	421	56	84	383										
154036	rapakivi	66,18	0,81	14,74	4,24	0,67	0,07	0,72	2,47	3,48	4,90	0,25	1,06																			
154038	rapakivi	60,33	0,84	17,65	5,51	0,56	0,08	1,18	4,01	3,92	4,09	0,30	1,27																			
154040	rapakivi	62,71	0,60	17,33	3,86	0,59	0,07	0,52	3,02	3,77	5,46	0,20	1,16																			
154045	rapakivi	62,11	0,69	17,39	4,53	0,50	0,07	0,80	3,11	3,79	4,77	0,24	1,57																			
Median		62,54	0,70	17,29	4,39	3,02	0,07	0,85	3,07	3,50	4,77	0,25	1,11	1320	102	15	21	115	291	40	95	434										
Number		*8*	*8*	*8*	*4*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*0*	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*										
154060	porphyritic bt-granite	68,92	0,61	14,15	3,21	0,72	0,05	0,95	2,00	2,98	4,83	0,24	0,60	916	30		13	201	272	35	96	241										
154062	porphyritic bt-granite	66,70	0,77	14,48	3,84	0,91	0,06	1,23	2,29	3,01	4,40	0,26	1,34					156	337													
154046	aplite granite	70,60	0,44	13,95	2,51	0,15	0,03	0,49	1,34	2,89	6,05	0,13	0,60					191	168													
154051	aplite granite	68,86	0,57	14,49	2,63	0,65	0,04	0,69	1,64	3,05	5,55	0,20	0,73	965	16		6	214	198	21	84	414										
154053	aplite granite	68,69	0,64	14,65	2,63	0,64	0,04	0,75	1,70	3,19	5,42	0,22	0,58					182	269													
154058	porphyritic bt-granite	68,25	0,68	14,32	3,54	0,87	0,06	1,09	2,06	3,01	4,39	0,26	0,76					193	287													
252901	granite	74,00	0,16	13,16		1,56	0,02	0,25	0,66	2,79	6,77	0,18	0,23	227				266	86			111										
252903	microcline granite	73,56	0,33	13,94		2,15	0,03	0,38	1,17	3,18	5,70	0,08	0,29	839				251	144			205										
289532	granite	70,83	0,26	15,02		2,30	0,05	0,86	2,20	4,07	4,20	0,13	0,33	1128				160	505			186										
Median		68,92	0,57	14,32	2,92	0,87	0,04	0,75	1,70	3,01	5,42	0,20	0,60	916				193	269			205										
Number		*9*	*9*	*9*	*6*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*9*	*5*	*2*	*0*	*2*	*9*	*9*	*2*	*2*	*5*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Metapsammite																																
252920	metapsammite	71,16	0,33	14,29		3,41	0,05	0,41	2,12	3,99	3,74	0,08	1,26	1139				137	752			219										
252921	metapsammite	65,65	0,39	16,78		3,31	0,06	1,38	3,31	4,66	3,22	0,15	0,22	1044				66	758			169										
252924	metapsammite	71,15	0,3	13,55		2,89	0,05	0,53	1,13	3,93	4,71	0,08	0,25	1309				163	338			254										
252926	metapsammite	69,61	0,3	15,48		2,68	0,06	0,8	2,83	4,31	2,61	0,1	0,25	933				92	1695			158										
413046	chip, psammite																						0,18	12,68	3,65	0,35	0,03	0,57	2,47	3,84	0,05	*23,82*
413047	chip, psammite																						0,17	12,05	2,33	0,50	0,03	1,09	1,98	4,12	0,07	*22,34*
413048	chip, psammite																						0,18	11,56	3,47	0,63	0,04	1,04	1,81	3,60	0,06	*22,40*
413051	chip, psammite																						0,22	11,20	2,62	0,70	0,03	0,90	1,09	4,04	0,06	*20,85*
413052	chip, psammite																						0,43	10,47	4,42	1,26	0,05	0,84	0,78	3,36	0,13	*21,74*
Median		70,38	0,32	14,89		3,10	0,06	0,67	2,48	4,15	3,48	0,09	0,25	1092				115	755			194	0,18	11,56	3,47	0,63	0,03	0,90	1,81	3,84	0,06	22,34

Niaqornaarsuk peninsula

Drainage	1	1	2	2	3	3	4	4	5	5	Weighted average	Weighted average
	SS	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith
SiO_2	64,84	66,74	63,4	66,84	52,8	66,74	55,4	67,59	64,38	66,33	**60,65**	66,80
TiO_2	0,866	0,46	1,078	0,46	1,02	0,46	0,83	0,47	0,65	0,48	**0,91**	0,47
Al_2O_3	14,66	16,46	14,49	16,41	14,7	16,46	15,9	16,51	14,33	16,49	**14,72**	16,46
Fe_2O_3	5,143	3,70	6,351	3,69	8,4	3,70	7,41	3,73	3,84	4,14	**6,21**	3,77
MnO	0,092	0,06	0,111	0,06	0,11	0,06	0,14	0,06	0,07	0,06	**0,10**	0,06
MgO	2,426	1,01	1,994	1,00	2,67	1,01	1,82	1,00	1,52	1,01	**2,15**	1,01
CaO	4,501	3,81	4,818	3,77	3,39	3,81	3,67	3,74	4,18	3,72	**4,19**	3,78
Na_2O	3,69	4,45	3,45	4,44	2,65	4,45	2,94	4,43	3,43	4,33	**3,27**	4,43
K_2O	1,896	1,85	2,337	1,89	1,98	1,85	2,15	2,00	1,83	2,16	**2,04**	1,92
P_2O_5	0,29	0,18	0,289	0,18	0,23	0,18	0,29	0,18	0,21	0,19	**0,26**	0,18
vol	1,63	0,66	0,685	0,65	10	0,66	5,78	0,67	5,05	0,70	**4,26**	0,66
As	0	1,3	0	1,3	9	1,3	6	1,2	0	1,6	**2,7**	1,3
Au	0	11,0	0	10,7	6	11,0	14	10,6	5	9,8	**3,8**	10,7
Ba	590	1029	540	1030	530	1029	740	1036	510	1058	**570**	1035
Co	13	35	14	34	14	35	18	34	13	32	**14**	34
Cr	43	50	49	49	41	50	39	49	56	55	**46**	50
Cs	0	1,1	3	1,1	2	1,1	5	1,2	3	1,2	**2,3**	1,1
Cu	20	19	27	19	31	19	31	19	13,5	18	**24**	19
Hf	10	5,3	16	5,3	9	5,3	8	5,3	16	5,6	**12,0**	5,4
Ni	1	0	32	0	48	0	35	0	16	2	**25**	0
Pb	9	7,5	15,5	7,7	19	7,5	19	8,3	7	9,1	**13,7**	7,9
Rb	48	26	56	29	77	26	73	32	52	37	**60**	29
Sb	0	0,50	0	0,49	0,3	0,50	0,5	0,49	0,4	0,48	**0,19**	0,49
Sc	17	5,8	21	5,7	16	5,8	18	5,9	16	6,5	**17,8**	5,9
Sr	448	650	417	637	473	650	376	638	401	604	**429**	638
Th	5,8	6,9	9,2	7,0	6,7	6,9	8	7,4	11	6,8	**8,0**	6,9
U	6	1,9	10	1,9	16	1,9	15	2,0	19	1,9	**12,4**	1,9
V	68	61	80	60	118	61	48	60	44	59	**75**	60
Y	41	12	53	12	36	12	46	12	39	15	**43**	12
Zn	73	52	116	52	146	52	151	52	92	56	**112**	52
Zr	330	138	500	139	345	138	287	141	552	167	**406**	143
La	41	30	49	30	68	30	78	30	55	31	**56**	30
Ce	60	58	87	58	92	58	100	58	100	61	**85**	58
Nd	35	21	38	21	50	21	55	21	43	23	**43**	21
Sm	5,7	4,9	6,6	4,8	7,8	4,9	9,1	4,9	6,4	5,1	**6,9**	4,9
Eu	1,5	1,2	1,8	1,2	2	1,2	2	1,2	1,6	1,2	**1,8**	1,2
Tb	0,9	0,28	1,2	0,28	1,2	0,28	1,3	0,28	1,2	0,35	**1,14**	0,29
Yb	3,52	1,3	4,39	1,3	2,62	1,3	3,31	1,4	3,22	1,6	**3,5**	1,4
Lu	0,46	0,23	0,56	0,23	0,39	0,23	0,43	0,24	0,46	0,27	**0,47**	0,24

Tabel A2.

Nanortalik peninsula

Drainage	**6**	6	**7**	7	**8**	8	**9**	9	**10**	10	**11**	11
	SS	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith
SiO_2	59,4	66,03	68,5	67,58	65,8	70,38	66,8	70,38	64,8	70,07	65,4	70,10
TiO_2	1,09	0,48	0,67	0,40	0,63	0,32	0,36	0,32	0,54	0,33	0,53	0,36
Al_2O_3	15	16,21	13,4	14,97	14	14,89	14	14,89	14,2	14,97	13,1	14,78
Fe_2O_3	7,7	4,22	8,78	4,37	4,76	3,10	3,39	3,10	5,34	3,28	4,82	3,30
MnO	0,12	0,07	0,07	0,08	0,08	0,06	0,05	0,06	0,08	0,06	0,07	0,05
MgO	3,61	1,29	1,87	1,36	1,22	0,67	1,4	0,67	1,39	0,68	1,78	0,68
CaO	6,49	3,93	4,25	3,20	1,98	2,48	1,86	2,48	2,05	2,50	1,83	2,32
Na_2O	3,04	4,29	2,73	3,92	2,66	4,15	3,04	4,15	2,87	4,12	2,87	3,93
K_2O	1,84	2,03	2,54	3,28	4,01	3,48	3,92	3,48	3,69	3,52	3,68	3,86
P_2O_5	0,33	0,18	0,13	0,12	0,22	0,09	0,15	0,09	0,16	0,10	0,16	0,11
vol	1,24	0,68	0,77	0,46	4,3	0,25	3,06	0,25	3,05	0,28	4,74	0,32
As	9	1,3	33	1,9	7	2,0	3,5	2,0	4,5	2,1	6	1,6
Au	0	9,1	0	0,3	0	0,0	0	0,0	0	0,0	0	0,0
Ba	360	1048	565	1104	690	1092	730	1092	705	1100	580	1057
Co	23	32	14	13	9	9	4,5	9	10	9	7	12
Cr	100	49	60	27	47	17	109	17	89	20	87	15
Cs	4	1,4	5	2,3	6	2,0	5,5	2,0	4	2,0	6	2,6
Cu	33	17	28	7	15	7	6	7	13	7	22	6
Hf	12	5,1	8,5	4,7	10	5,1	6	5,1	13,5	5,2	10	4,9
Ni	19	2	32	10	25	8	22	8	28	8	19	7
Pb	16	8,6	16	16,6	6,5	18,0	11	18,0	9	18,2	8,5	20,7
Rb	79	40	82	111	127	115	111	115	127	114	128	130
Sb	0,8	0,48	1,4	0,27	1,7	0,20	1,2	0,20	0,85	0,21	1,6	0,16
Sc	23	7,8	14	9,4	8,1	4,9	7	4,9	8,6	5,2	7,7	4,8
Sr	395	573	271	156	264	110	260	110	288	117	262	141
Th	8,2	7,2	8,7	11,6	13	13,0	7,9	13,0	16,5	12,7	11	14,9
U	7	2,0	14	3,0	12	3,4	19	3,4	45	3,4	38	3,4
V	117	67	67	48	33	22	27	22	40	23	37	18
Y	42	12	32	11	35	10	26	10	41	11	31	12
Zn	95	54	85	54	66	47	48	47	66	49	57	48
Zr	342	142	316	181	356	194	347	194	509	202	417	196
La	37	30	38	34	58	38	40	38	60	38	53	37
Ce	69	57	71	67	120	73	68	73	110	74	94	72
Nd	33	21	26	28	45	30	28	30	45	31	36	30
Sm	6,6	4,9	4,7	4,9	8	4,9	4,7	4,9	7,55	5,0	6,3	5,0
Eu	1,8	1,2	1,1	1,0	1,4	0,9	1,05	0,9	1,55	0,9	1,3	0,9
Tb	1,3	0,30	0,95	0,60	1	0,70	0,65	0,70	1,05	0,71	0,9	0,68
Yb	4,17	1,5	2,89	2,4	2,84	2,4	2,11	2,4	3,44	2,5	2,71	2,3
Lu	0,55	0,26	0,40	0,40	0,39	0,39	0,33	0,39	0,51	0,40	0,32	0,37

Table A2 continued.

Sermersooq

Drainage	**12**	12	**13**	13	**14**	14	**15**	15	**16**	16	Weighted average	Weighted average	**17**	17
	SS	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith	**SS**	Lith
SiO_2	58,6	65,98	60,7	66,83		65,43	50,6	68,63	59,1	65,82	**60,16**	67,79	56,79	66,37
TiO_2	0,75	0,55	0,7	0,49		0,63	1,08	0,43	0,63	0,49	**0,70**	0,43	1,02	0,54
Al_2O_3	14,1	15,06	14,1	14,96		14,56	14,7	14,75	12,5	15,05	**13,58**	15,10	16,64	15,36
Fe_2O_3	5,08	5,40	6,19	4,90		5,62	8,62	4,00	4,61	5,30	**5,87**	4,25	9,49	5,90
MnO	0,07	0,07	0,09	0,07		0,07	0,08	0,06	0,09	0,09	**0,08**	0,07	0,11	0,06
MgO	1,74	1,42	1,88	1,36		1,69	1,86	1,02	2,16	1,66	**1,96**	1,16	2,14	1,22
CaO	2,58	2,97	2,71	2,97		2,86	1,57	2,58	4,24	3,40	**3,16**	2,98	1,79	2,77
Na_2O	2,56	3,38	2,94	3,56		2,94	1,81	3,70	2,44	3,61	**2,64**	3,85	2,50	2,82
K_2O	3,45	4,22	2,9	3,93		4,72	2,82	3,97	1,91	3,57	**2,86**	3,50	4,06	4,42
P_2O_5	0,3	0,18	0,19	0,16		0,21	0,31	0,13	0,18	0,15	**0,21**	0,14	0,20	0,19
vol	10	0,71	4,07	0,60		0,81	16	0,45	11,8	0,64	**5,84**	0,50	5,19	0,73
As	34	1,4	13,5	1,5	59	0,3	66	1,3	52,5	1,7	**25,4**	1,6	20	5,7
Au	0	0,4	0	0,3	0	0,4	3,5	0,1	5,5	0,5	**1,1**	1,4	0	1,3
Ba	410	1065	595	1069	430	972	480	1045	625	1095	**558**	1074	510	991
Co	12	20	12,5	18	19	29	10,5	16	17,5	18	**13**	17	16	16
Cr	53	33	89,5	28	56	21	43	18	74	34	**77**	28	38	69
Cs	7	3,7	5	3,3	5	5,0	8,5	3,1	4,5	3,0	**5,4**	2,6	5	3,4
Cu	37	6	21	6	26	3	14	6	46	7	**25**	8	50	36
Hf	12	4,9	13,5	4,8	28	3,9	14,5	4,7	20,5	4,6	**12,7**	4,9	16	6,2
Ni	31	10	31	9	5	7	19	7	44	10	**27**	8	26	22
Pb	15,5	22,9	14	21,1	11	27,0	12	21,6	16	18,5	**13,2**	18,2	25	27,0
Rb	135	142	99,2	133		170	202	136	61	121	**107**	114	262	126
Sb	1	0,21	1,25	0,22	7,3	0,14	1,05	0,17	0,7	0,27	**1,23**	0,25	0	0,33
Sc	16	10,0	12,5	9,4	16	10,7	13	6,9	16,5	11,5	**13,6**	7,9	13	9,3
Sr	204	243	262	211	203	297	168	180	167	209	**254**	228	192	313
Th	19	14,6	15	14,0	48	18,9	14	15,3	22	12,1	**14,4**	12,7	21	11,0
U	43	2,9	21	3,0	31	3,0	24	3,3	26	2,8	**24,6**	3,0	30	3,9
V	45	41	60	41		40	110	28	111	56	**69**	40	60	50
Y	40	20	44	16	68	20	43	14	37	15	**38**	13	60	26
Zn	84	62	85	58	122	60	61	52	105	61	**79**	54	132	101
Zr	481	218	497	201	627	185	582	191	337	191	**417**	189	551	297
La	74	34	64	34	120	31	84	35	71	33	**58**	35	85	38
Ce	120	67	120	67	230	60	125	68	155	64	**107**	67	160	75
Nd	58	31	57	30	110	28	69	29	64	29	**47**	28	81	34
Sm	9,7	5,5	9,15	5,3	20	5,5	9,05	5,1	12,3	5,2	**8,1**	5,1	14	5,9
Eu	1,1	1,0	1,7	1,0	2,2	0,9	1,15	0,9	1,8	1,0	**1,4**	1,0	2,4	1,2
Tb	1,4	0,60	1,40	0,60	2,3	0,48	1,15	0,62	2,15	0,56	**1,27**	0,58	2	0,81
Yb	3,51	2,4	3,54	2,4	6,47	2,0	3,79	2,2	5,07	2,4	**3,6**	2,3	5,43	3,2
Lu	0,4	0,38	0,41	0,38	0,94	0,32	0,43	0,36	0,65	0,40	**0,46**	0,37	0,75	0,46

Table A2 continued.