DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2001/47

Calibration of stream sediment data from West and South Greenland

A supplement to GEUS Report 1999/41

Agnete Steenfelt

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Abstract

This report is a supplement to GEUS Report 1999/41 describing methods employed for selecting and calibrating stream sediment data for a geochemical atlas of West and South Greenland. A supplement was required because the atlas has been enlarged to include recently collected data in northernmost West Greenland. The present report contains tables and figures that needed updating because of the addition of new data, and it describes a number of minor corrections and data adjustments made since the former report.

Introduction

Geochemical mapping of Greenland based on chemical analysis of systematically collected stream sediment samples has been carried out by the Geological Survey of Denmark and Greenland (Geological Survey of Greenland prior to 1995) since 1974 with financial support from Bureau of Minerals and Petroleum, Government of Greenland, since 1993. Now almost half of the ice-free land surface of Greenland is covered and analytical data have been compiled for presentation of 'Geochemical atlas of Greenland–West and South Greenland'. The atlas is published on CD-ROM as well as on paper (Steenfelt 2001).

Quality assessment and calibration (levelling) of analytical data to eliminate bias between individual sample batches submitted for analysis have been crucial to the production of reliable element distribution maps. The methods and principles employed for compilation and calibration of stream sediment analytical data from West and South Greenland are described in GEUS report 1999/41 (Steenfelt 1999a). Originally, the geochemical atlas was planned to comprise the Precambrian of West Greenland from 70°30' northern latitude southwards, see Fig. 1. Later, however, it was decided to include stream sediment data from northern West Greenland (Steenfelt *et al*. 1998, 1999) into the geochemical atlas, so that the present coverage is as shown in Fig. 1. Quality assessment and calibration of the additional data needs documentation. At the same time an updating of the bibliography contained in GEUS report 1999/41 is appropriate.

The present report must be regarded as a supplement to GEUS report 1999/41, and text concerning record of sampling and analysis, description of analytical methods and discussion of methods is not repeated here. However, all tables and figures serving as documentation of the selection and calibration of the entire database behind the element distribution maps of the atlas are included with additions and corrections where appropriate.

Sampling and analysis within areas UM and UP, northern West Greenland

The sampling procedure was the same as used in the rest of the atlas area, and sample density was between one per 20 km^2 and one per 30 km^2 of ice-free land surface. The samples were analysed for major elements by X-ray Fluorescence Spectrometry (XRF) and

for trace elements by Instrumental Neutron Activation Analysis (INA) and Inductively Coupled Plasma Emission Spectrometry (ICP)*, see Table 4. Budget constraints did not permit trace element analysis of batch UM by XRF. Thus, Nb and Zr data are missing for batch UM, and Ba and Rb data are taken from Act INA results. The latter are generally less reliable than the corresponding data determined by Act XRF, see Figs 14a and 14g, and GEUS report 1999/41. For batch UP, ICP and Act INA data are preferred, and only Zr data were taken from GGU XRF.

* A 'near total' digestion using HF, $HClO_4$, HNO_3 and HCl is employed.

Additions, changes and corrections

During the production of the geochemical atlas some errors were found in report 1999/41, and minor improvements in the calibration for certain elements were found desirable. The corrections and changes made in the corresponding tables and figures of this supplementary report are summarised here and further described as necessary.

Correction of errors in GEUS report 1999/41:

Two literature references found missing in the bibliography

Fig. 13d, the diagram displays Co-variation in stead of Hf-variation

Changes in data selection

12 samples (330922-330933) in batch C are not proper stream sediments and are excluded

Changes of calibration parameters

Table 6: Reference values for Sc are changed, hence all Sc corrections changed

Table 7a: Correction of Na_2O in batch L1 was required and necessitated small corrections for all other major elements

Table 7b: changes made for Ce, Sc, Sm, Th, Yb where minor bias still existed

Table 7c: changes made for Cr, Sr, Rb where minor bias still existed

Table 7c: correction of Ga data for batches J1 and J2 was required

Addition of data

Tables 1, 2, 4, 5, and 7 as well as Figs 12 to 14 are updated to include data from areas sampled in 1997 and 1998

Measurements of gamma-radiation have been included

Updating of bibliography with publications relating to the new areas and those issued since GEUS report 1999/41 (Steenfelt 1999a).

Correction of Na_2O in batch L1

As shown in Table 2, samples in batch L1 were analysed by GGU XRF (X-ray Fluorescence Spectrometry at the Geological Survey of Greenland) before the internal standards were introduced. Major element analyses by GGU XRF have always had high precision and have been monitored by international reference material. The very small variations in

repeated analyses of the internal standards used in the geochemical mapping programme (Fig. 12 and Steenfelt, 1999b) confirm the stability in major element analyses. However, when the map of Na_2O was produced, an area with lowered values was seen to correspond to the distribution of samples from batch L1. The suspected analytical bias was examined using the results of reanalysis of selected samples from a number of previously analysed batches. The results for Na_2O are shown in the diagram, Fig. 12k, which demonstrates that the strongest bias is, in fact, affecting samples from batch L1. The diagram also shows how the Na_2O results can be corrected by linear regression.

Analytical results for Na are reported from the XRF-laboratory together with the results for other major elements as oxide percentages. However, Na is determined by AAS (Atomic Absorption Spectrometry) and recalculated as Na_2O. When the major element percentages are calculated as volatile-free, it implies that if Na_2O is increased the other components have to be proportionally decreased to maintain the original sum.

Correction of Ga in batches J1 and J2

Ga is included in the X-ray Fluorescence (XRF) analytical packages from Risø National Laboratory (Risø) and Activation Laboratories Ltd. (Act). The Risø analyses were made without, while Act analyses were made together with internal standards. The variation in Ga concentrations determined in the standards is shown in Fig. 14d. The compatibility of Risø data with Act data was tested for 26 samples from batch J2 and 27 samples from batches O1 to O5, see Figs 17g and 19e of GEUS report 1999/41, respectively. The results were inconclusive, however, and it was deemed impossible to correct the Risø-data for Ga by the regression method.

In the distribution map for Ga, the data for area O seemed reasonable, while data for area J were clearly too low. Fig. 2 was then constructed to illustrate the character of the bias. The internal variation among samples from area J is of roughly the same magnitude as in neighbouring areas (I and K), and the bias is interpreted as an error in the background correction of the XRF-spectrum. It has, therefore, been decided to elevate the data from area J to match the typical level of area K, so that the medians for the two data populations are the same. The assumption that the two areas should have the same median for Ga is probably not entirely safe, and this should be kept in mind in any interpretation of the regional variation. However, the advantage is that any regional variation in Ga distribution within area J, as well as within neighbouring areas, can be displayed in the same colour scaling. Taking into consideration the overall uncertainty in determining Ga at low concentrations (Fig. 14d), precaution is recommended under all circumstances when interpreting the distribution map of Ga.

Changes in calibration parameters

The change in calibration for Ce (Table 7b) has influenced the calibration of B-C values to Act INA values portrayed in Fig. 16. In addition, it was decided to calibrate batches A, B and C individually for Sm, to correct a mistake in the calibration of B-C values for Th, and to

calibrate B-C values for U in batch C. A new Fig. 16 with modifications to Figs 16a (Ce), 16d (Sm) and 16h (U) has been produced.

Calibration of gamma-radiation measurements

Total radiation, i.e. gamma rays emitted during decay of radioactive isotopes of U, Th and K in the rocks, is measured by scintillometer at each stream sediment sample. Two different makes of scintillometer have been used. Saphymo-Srat SPP2 instruments in all areas except South Greenland (area O), where Scintrex BGS instruments were used.

Readings by SPP2-scintillometers have been recorded in counts per second (cps). Individual instruments exposed to the same source may differ in their readings within about 10 %, and the performance of the instruments has changed slightly over the years. However, the same six instruments have been used throughout the sampling of West Greenland, and the gamma-radiation level recorded at each site is regarded as stable within the uncertainty associated with acquiring an estimated average for each site of a parameter highly dependant on radon emission.

Readings from area O have been recalculated to the unit of radioactivity, Ur, and stored as such in the database of the 'South Greenland uranium exploration project' (see GEUS report 1999/41, section on 'Record of sampling'). The original counts-per-second-readings are not stored. The calculation of Ur-values was possible because the BGS-instruments had been calibrated on calibration pads at Risø National Laboratory (Risø). The SPP2 scintillometers have also been calibrated at Risø, and the relation between BGS-counts and SPP2-counts is known (on average SPP2-counts = 0.74 BGS-counts). Using calibration parameters reported by Risø, it was attempted to transform the Ur-values (back) to counts per second (cps). The exercise had to involve some empirical adjustment because of uncertainty of how background radiation had been used in the calculation of Ur-values. The preferred calibration equation is cps = Ur *3.83 + 10.

Another, in principle more correct, way of levelling radiation data between area O and the remaining areas would be to calculate Ur values from SPP2 readings. This has not been chosen because of the above mentioned problems of applying the background correction suggested in the data from Risø. Routine calibration of scintillometers was discontinued almost ten years ago, and the calibration pads at Risø have been dismantled. The solution to this problem would, therefore, require more consultation and renewed calibration, and this was not felt justified for the purpose of the geochemical atlas.

The above considerations illustrate that the cps-values used to construct the map of gamma-radiation are, by nature and by recording technique, not very accurate. However, the regional variation in gamma-radiation, as shown by the map, by far exceeds the uncertainty, and can confidently be interpreted to reflect variation in the sum of U, Th and K concentrations of the rocks.

Tables and figures

The following pages contain tables and figures. Tables and figures representing updated versions of tables and figures in GEUS report 1999/41 have been given the same numbers to ease comparison. The list shows where to find the tables and figures.

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Table 1. *List of stream sediment surveys contributing to the geochemical atlas*

Year of sampling	Area code	Survey name and map sheet	Survey character	Sampling density	Responsible collector
1977	G	Ndr.Str., 67 V1	Local U exploration	Detailed*	M. Watt
1979	L	Ghb 79, 64 V	Local U exploration	Irregular*	A. Steenfelt
1979	O	Syduran, 59-61 V	Regional U exploration	1 per 5-6 km^2	A. Armour-Brown
1981	I	66 V2	Geochemical mapping	1 per 25-30 km^2	A. Steenfelt
1981	K	AST reco, 65 V1	Local U exploration	Irregular*	A. Steenfelt
1981	L	AST reco, 64 V	Local U exploration	Irregular*	A. Steenfelt
1982	I	66 V2	Geochemical mapping	1 per 25-30 km^2	K. Holme
1982	J	65 V2	Geochemical mapping	1 per 25-30 km^2	K. Holme
1985	M	PA reco 63 V1	Tungsten exploration	Irregular*	C. Clausen
1986	B	69-70 V2	Geochemical mapping	1 per 25-30 km^2	A. Steenfelt
1986	I	66 V2	"Filling of gaps"	1 per 25-30 km^2	A. Steenfelt
1986	L	64 V	Geochemical mapping	1 per 25-30 km^2	A. Steenfelt
1988	A	Nuussuaq, 70 V2	Geochemical mapping	1 per 25-30 km^2	A. Steenfelt
1989	C	Ilimanaq, 68 V2	Geochemical mapping	1 per 25-30 km^2	A. Steenfelt
1989	UM	Íngia	Local Au exploration	Detailed*	B. Thomassen
1990	UM	Íngia	Local Au exploration	Detailed*	B. Thomassen
1990	H	67 V2	Geochemical mapping	1 per 25-30 km^2	A. Steenfelt
1991	E	Chr. Håb, 68 V2	Geochemical mapping	1 per 25-30 km^2	J. P. Nielsen
1991	M	Buksefj., 62-63 V	Geochemical mapping	1 per 25-30 km^2	P. Erfurt
1992	F	66+67 V1	Geochemical mapping	1 per 25-30 km^2	A. Steenfelt/J.P. Nielsen
1992	P	Suprasyd, 60-61 Ø	Geochemical mapping	1 per 25-30 km^2	P. Erfurt
1992	UM	Íngia	Local Au exploration	Detailed*	B. Thomassen
1993	D	Aasiaat, 68 V1	Geochemical mapping	1 per 25-30 km^2	A. Petersen
1993	I	66 V2	"Filling of gaps"	1 per 25-30 km^2	A. Steenfelt
1993	K	Maniitsoq, 65 V1	Geochemical mapping	1 per 25-30 km^2	A. Steenfelt
1993	L	64 V	"Filling of gaps"	1 per 25-30 km^2	A. Steenfelt
1993	M	63 V1	"Filling of gaps"	1 per 25-30 km^2	A. Steenfelt
1993	N	Paamiut, 61-62 V1	Geochemical mapping	1 per 25-30 km^2	A. Steenfelt
1997	UM	Karrat '97,70-72 V	Geochemical mapping	1 per 25-45 km^2	A.Steenfelt/J. Kyed
1998	UP	Upernavik '98,73-75 V	Geochemical mapping	1 per 35-50 km^2	J. Kyed

** A number of samples with a spacing corresponding to 1 sample per 25 km^2 were selected for the atlas.*

Table 2. *List of sample batches contributing to the atlas and their analyses. This illustrate the amount of available analytical data, from which the most reliable data are selected, see Table 4.*

Area code	Batch code	Survey name or map sheet	Year of sampling	Stream sediment sample series	Total selected	Total major		Total trace							
						GGU XRF	Act XRF	Act XRF	GGU XRF	GGU *Cu	Risø XRF	Risø DNC	Act INA	B-C INA	Act ICP
A		Nuussuaq	1988	330701-836	89	*89*			*89*	*89*		*56*	8	*73*	
B		69+70 V2	1986	330401-668	265	*265*			*265*	260		*101*	5	*131*	
C		Ilimanaq	1989	330901-921,934-971	55	55		43	66	0			8	*60*	
D		Aasiaat	1993	381966-382060	90	88		86	88	88			90		
E		Chr. håb	1991	380001-303	266	247		219	247	247			266		
F		66+67 V1	1992	380401-381149	705		582	679					693		
G		Ndr.Str.	1977	193001-598	59		48	48			*59*	*59*	59		
H		67 V2	1990	368001-367	351	342		262	342	342			351		
I	I1	66 V2	1981	306001-150,306201-251	175	174		125	174	174	*175*	*175*	163		
	I2	66 V2	1982	306401-548	123	*123*		112	*123*	*123*	*123*	*123*	121		
	I3	66 V2	1986	330670-695	10	*10*			*10*	*10*		*2*		*2*	
J		65 V2	1982	309101-700,301701-754	392	*387*		26	*387*	0	*390*	*392*	185	*354*	
K	K1,K2	65 V1	1993	381742-965	211	185		173	185	185			211		
	K3	AST reco	1981	306301-336	4	4			4	4	*4*	*4*	3		
L	L1	64 V1+2	1986	330001-330340	311	*311*			*310*	0		*123*	159	*98*	154
	L2	Ghb 79	1979	263124-392	24	24			24	24	*24*	*24*	24		
	L3	AST reco	1981	306337-367	4	4			4	4	*4*	*4*	3		
	L4	64 V1+2	1993	381725-741	17	11		7	11	11			17		
M	M1,M2	63 V1+2	1991	386001-500	273	219		209	219	219			273		
	M3	63 V1	1993	381692-724	31	31		22	31	31			31		
	M4	PA reco	1985	329501-583	26	24			11	11			19		
N		Paamiut	1993	381401-691	275	216		211	216	216			275		
O		Syduran	1979	280002-282926	2415	1072		27	1072	1072	*2281*	*2254*	*2185*		
P		Suprasyd	1992	386701-845	141		132	140					141		
UM	UM1-4,UM7	Uummannaq	1997	501001-501568	528		517						528		524
	UM5	Íngia detail	1989	350710-746	14		14						14		14
	UM5	Íngia detail	1990	366102-158	18		18						18		18
	UM6	Íngia detail	1992	386902-930	12		10						12		12
UP	UP1-3	Upernavik	1998	501601-850	238	197							238		229
Grand total					7122	4078	1321	2389	3878	3110	3060	3317	6100	718	951

Numbers in italics mark analyses made without internal standards.

Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);* Risø *(Risø National Laboratory); B-C (Bondar-Clegg and Co. Ltd.).*
Methods: XRF *(X-ray Fluorescence Spectrometry);* DNC *(Delayed Neutron Counting);* INA *(Instrumental Neutron Activation);*
ICP *(Inductively Coupled Plasma Emission Spectrometry). * Cu analyses at GGU are made by Atomic Absorption Spectrometry.*

Table 3a. *Major elements determined in analytical packages*

XRF glass		XRF powder	AAS	INA		ICP
GGU	Act	Risø plu	GGU	Act	B-C	Act
SiO_2	SiO_2					
TiO_2	TiO_2	Ti				Ti
Al_2O_3	Al_2O_3					Al
Fe_2O_3	Fe_2O_3			Fe	Fe	
MnO	MnO	Mn				Mn
MgO	MgO					Mg
CaO	CaO	Ca		Ca		Ca
	Na_2O		Na	Na	Na	
K_2O	K_2O	K				K
P_2O_5	P_2O_5					P
L.o.i.	L.o.i.					

L.o.i.: *Loss on ignition.*
Methods: XRF *(X-ray Fluorescence Spectrometry);* plu *(XRF with plutonium source);*
AAS *(Atomic Absorption Spectrometry);* INA *(Instrumental Neutron Activation);*
ICP *(Inductively Coupled Plasma Emission Spectrometry).*
Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);*
Risø *(Risø National Laboratory);* B-C *(Bondar-Clegg and Co. Ltd.).*

Table 3b. *Trace elements determined in analytical packages.*

XRF glass GGU		XRF powder Act		XRF powder Risø plu		XRF powder Risø cd		INA Act		INA B-C		ICP Act	
	l.l.d.		l.l.d.		l.l.d.		l.l.d.		l.l.d.		l.l.d.		l.l.d.
								Ag	5	Ag	5	Ag	0.5
								As	2	As	1		
								Au	0.005	Au	0.005		
Ba	100	Ba	5					Ba	100	Ba	100		
								Br	1	Br	1		
										Cd	10	Cd	0.5
								Ce	3	Ce	10		
		Co	5					Co	5	Co	10		
Cr	50	Cr	5	Cr	50			Cr	10	Cr	50		
								Cs	2	Cs	1		
*Cu	5	Cu	5	Cu	10							Cu	1
								Eu	0.2	Eu	2		
		Ga	5	Ga	10								
								Hf	1	Hf	2		
								Hg	1				
								Ir	5	Ir	100		
								La	1	La	5		
								Lu	0.05	Lu	0.5		
						(Mo)	20	Mo	5	Mo	2	Mo	2
(Nb)	50	Nb	2			Nb	20						
								Nd	5				
Ni	50	Ni	5	Ni	10			Ni	50	Ni	20	Ni	1
		(Pb)	5	(Pb)	10							Pb	5
Rb	50	Rb	2			Rb	20	Rb	30	Rb	10		
								Sb	0.2	Sb	0.2		
								Sc	0.1	Sc	0.5		
								Se	5	Se	10		
								Sm	0.1	Sm	0.2		
								Sn	100	Sn	200		
Sr	50	Sr	2			Sr	20	Sr	500			Sr	1
								Ta	1	Ta	1		
								Tb	0.5	Tb	1		
										Te	20		
								Th	0.5	Th	0.5		
				**U	0.016			U	0.5	U	0.5		
V	50	V	5	(V)	50							V	2
								W	4	W	2		
(Y)	100	Y	2			Y	20					Y	2
								Yb	0.2	Yb	5		
Zn	50	Zn	5	Zn	10			Zn	50	Zn	200	Zn	1
Zr	50	Zr	5			Zr	20			Zr	500		

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: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);* Risø *(Risø National Laboratory);* B-C *(Bondar-Clegg and Co. Ltd.).*
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 4. *Analytical data sets selected for the atlas.*

Batch code	Major elements	Non-calibratable trace elements by INA and DNC			Calibratable trace elements by INA		Calibratable trace elements mainly by XRF		
		As,Au,Br,Cs, Mo,Sb,Ta,W	Nd,Lu	U	Eu,Yb	Ce,Co,Hf,La, Sc,Sm,Th	Ba,Cr	Ni,Sr	V
A	GGU*	B-C INA	no data	Risø DNC	no data	B-C INA*	GGU XRF*	GGU XRF*	GGU XRF*
B	GGU*	B-C INA	no data	Risø DNC	no data	B-C INA*	GGU XRF*	GGU XRF*	GGU XRF*
C	GGU	B-C INA	no data	B-C INA*	no data	B-C INA*	Act XRF	Act XRF	Act XRF
D	GGU	Act INA	Act INA	Act INA	Act INA	Act INA	Act XRF	Act XRF	Act XRF
E	GGU	Act INA	Act INA	Act INA	Act INA	Act INA	Act XRF	Act XRF	Act XRF
F	Act	Act INA	Act INA	Act INA	Act INA	Act INA	Act XRF	Act XRF	Act XRF
G	Act	Act INA	Act INA	Risø DNC	Act INA	Act INA	Act XRF	Act XRF	Act XRF
H1,H2	GGU	Act INA	Act INA	Act INA	Act INA	Act INA	Act XRF	Act XRF	Act XRF
I1	GGU	Act INA	Act INA	Risø DNC	Act INA	Act INA	Act XRF	Act XRF	Act XRF
I2	GGU*	Act INA	Act INA	Risø DNC	Act INA	Act INA	Act XRF	Act XRF	Act XRF
I3	GGU*	B-C INA	no data	Risø DNC	no data	B-C INA*	GGU XRF*	GGU XRF*	GGU XRF*
J1, J2	GGU*	Act INA	Act INA	Risø DNC	Act INA	Act INA	GGU XRF*	GGU XRF*	GGU XRF*
I4, K1, K2	GGU	Act INA	Act INA	Act INA	Act INA	Act INA	Act XRF	Act XRF	Act XRF
K3	GGU	Act INA	Act INA	Risø DNC	Act INA	Act INA	GGU XRF	GGU XRF	GGU XRF
L1	GGU*	Act INA	Act INA	Act INA+B-C INA	Act INA	Act INA	GGU XRF*	GGU XRF*	GGU XRF*
L2, L3	GGU	Act INA	Act INA	Risø DNC	Act INA	Act INA	GGU XRF	GGU XRF	GGU XRF
L4	GGU	Act INA	Act INA	Act INA	Act INA	Act INA	Act XRF	Act XRF	Act XRF
M1,M2,M3	GGU	Act INA	Act INA	Act INA	Act INA	Act INA	Act XRF	Act XRF	Act XRF
M4	GGU	Act INA	Act INA	Act INA	Act INA	Act INA	GGU XRF	GGU XRF	GGU XRF
N1, N2	GGU	Act INA	Act INA	Act INA	Act INA	Act INA	Act XRF	Act XRF	Act XRF
O1 to O5	GGU*	Act INA	Act INA	Risø DNC	Act INA*	Act INA*	Act INA*	Risø XRF*	GGU XRF
P	Act	Act INA	Act INA	Act INA	Act INA	Act INA	Act XRF	Act XRF	Act XRF
UM1 to UM7	Act	Act INA	Act INA	Act INA	Act INA	Act INA	Act INA	Act ICP	Act ICP
UP1 to UP3	GGU	Act INA	Act INA	Act INA	Act INA	Act INA	Act INA	Act ICP	Act ICP

* analysed without standards

Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);* Risø *(Risø National Laboratory); B-C (Bondar-Clegg and Co. Ltd.).*
Methods: XRF *(X-ray Fluorescence Spectrometry);* DNC *(Delayed Neutron Counting);* INA *(Instrumental Neutron Activation);*
ICP *(Inductively Coupled Plasma Emission Spectrometry, 'near total' HF, $HClO_4$, HNO_3, HCl digestion);* AAS *(Atomic Absorption Spectrometry).*

Table 4 *(continued)*

Batch code	Calibratable trace elements mainly by XRF						
	Rb	Zr	Zn	Nb	Y	Ga	Cu
A	GGU XRF*	GGU XRF*	GGU XRF*	GGU XRF(poor)	GGU XRF(poor)	no data	GGU AAS
B	GGU XRF*	GGU XRF*	GGU XRF*	GGU XRF(poor)	GGU XRF	no data	GGU AAS
C	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
D	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	GGU AAS
E	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
F	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
G	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
H1,H2	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
I1	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
I2	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
I3	GGU XRF*	GGU XRF*	GGU XRF*	GGU XRF(poor)	GGU XRF(poor)	no data	GGU AAS
J1, J2	Risø XRF*	Risø XRF*	Risø XRF*	Risø XRF*	Risø XRF*	Risø XRF*	Risø XRF*
I4, K1, K2	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	GGU AAS
K3	GGU XRF	GGU XRF	GGU XRF	Risø XRF*	Risø XRF*	Risø XRF*	GGU AAS
L1	GGU XRF*	GGU XRF*	GGU XRF*	GGU XRF(poor)	Act ICP	no data	Act ICP
L2, L3	GGU XRF	GGU XRF	GGU XRF	Risø XRF*	Risø XRF*	Risø XRF*	GGU AAS
L4	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
M1,M2,M3	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
M4	GGU XRF	GGU XRF	GGU XRF	GGU XRF	GGU XRF	no data	GGU AAS
N1, N2	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	GGU AAS
O1 to O5	Risø XRF*	Risø XRF*	Risø XRF*	Risø XRF*	Risø XRF*	Risø XRF*	Risø XRF*
P	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF	Act XRF
UM	Act INA	no data	Act ICP	no data	Act ICP	no data	Act ICP
UP	Act INA	GGU XRF	Act ICP	no data	Act ICP	no data	Act ICP

Table 5. *Identification numbers for sets of internal standards submitted together with sample batches and international standards (CANMET)*

Batch code	Stream sediment sample numbers	GGU XRF major+ trace std id#	Act XRF major std id#	Act XRF trace std id#	Act INA trace std id#	B-C INA trace std id#	Risø XRF trace std id#	Risø DNC U std id#	Act ICP trace std id#	GGU AAS Cu std id#
A	330701-836	none			98	none				155
B	330401-668	none			76 (few)	none				155.1,2
C	330901-921,934-971	11.0		148	98	none				
D	381966-382060	90		89	88					
E	380001-303	24.0		103	21					
F1	380401-600		53	52	51					
F2	380602-800		56	55	54					
F3	380801-381000		59	58	57					
F4	381001-149		62	61	60					
G	193001-598		72	71	25		none	none		
H1	368001-221	13.0		102	14					
H2	368222-367	13.1		102	14					
I1	306001-150,201-251	17		104	06,07,08		none	none		
I2	306401-548	none		104	06,07,08		none	none		
I3	330670-695	none				none		none		
J1	301701-754	none			135	none	none	none		
J2	309101-700	none			135	none	none	none		
K1	381742-900	85		84	83					
K2	381901-965	90		89	88					
K3	306301-337	75			76		none	none		
L1	330001-330340	none			133	none			133	
L2	263201-276,320-386	74			76		none	none		
L2	263124-200,278-298	75			76		none	none		
L3	306337-367	75			76		none	none		
L4	381725-741	81		148	87					
M1	386001-170	29		147	22					
M2	386171-500	29		148	22					
M3	381692-724	81		148	87					
M4	329501-583	75			76					
N1	381401-550	77		79	78					
N2	381551-691	81		82	80					
O1	280002-607	none			none					
O2	280608-281000	11.1			none					
O3	281002-281518	none			none					
O4	281519-835	24.1			none					
O5	281836-282926	18			none					
P	386701-845		49	48	47					
Jx	26 selected			156						
Ox	27 selected+CANMET			165						
	CANMET				66					
	CANMET	169								
UM1	501088-91,93-200,301-328,351-375		137		138				138	
UM2	501001-87,92,201-44,376-400		140		139				139	
UM3	501245-300,329-350,401-413		142		141				141	
UM4	501414-501568		145		144				144	
UM5	350710-746,366102-158		153		152				152	
UM6	386902-930		153		50				154	
UM7	501461,73,531				146				146	
UP1	501601-709,711-743	158			157				157	
UP2	501710,44-45,47-52,55-56,58-72,75-85,87-85	161			159				159	
UP3	501746,51,53-54,57,73-74,86,92				160				160	

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INA *(Instrumental Neutron Activation);* ICP *(Inductively Coupled Plasma Emission Spectrometry);*
AAS *(Atomic Absorption Spectrometry).* std *#: identification number of a standard set; see Steenfelt (1999a) for explanation of full id-numbers of individual standards within a set.*

Table 6. *Reference values for calibration of analytical values*

Major elements

Levels represent means of GGU XRF analyses of standard sets 74 to 94 calculated as volatile free.

	std 1	std 2	std 3	std 5
SiO_2	67.95	67.37	62.94	54.28
TiO_2	0.454	0.408	0.913	1.508
Al_2O_3	14.06	13.93	13.04	14.31
Fe_2O_3	4.32	4.70	6.76	11.25
MnO	0.08	0.09	0.10	0.17
MgO	2.80	3.64	5.14	8.54
CaO	4.36	3.24	5.43	6.72
Na_2O	3.67	3.66	3.16	1.59
K_2O	1.78	2.31	2.10	1.01
P_2O_5	0.18	0.11	0.20	0.14

Trace elements

XRF. Values represent medians of Act XRF analyses of standard sets 102 to 104, except for Cr, Zn and Rb.

	std 1	std 2	std 3	std 5	Comments
Ba	436	534	653	256	
Cr	205	249	668	1242	values are set equal to data by KU XRF
Cu	14.3	22.7	44	76	
Ga	very poor reproducibility, no calibration by regression				
Nb	10	6	4.7	9	
Ni	76	137	150	296	
Pb	very poor reproducibility, data not included in atlas				
Rb	60	78	48	28	values are set equal to data by KU XRF
Sr	255	251	269	168	
V	69	60	176	258	
Y	23.7	19.7	18.7	24.7	
Zn	40.3	58	43.7	77	reference is mean of std 52 to 61
Zr	378	165	456	231	

INA. Values are determined as medians of standard sets 51 to 135; or they are the same as for XRF.

	std 1	std 2	std 3	std 5	
Ba	436	534	653	256	
Co	16	20	29	50	
Cr	205	249	668	1242	values are set equal to data by KU XRF
Hf	15	6	17	8	
Rb	60	78	48	28	values are set equal to data by KU XRF
Sc	12	10.5	20	30	
Th	no obvious changes in the concentrations levels, corrections not justified				
U	corrections not justified				
La	28.27	28.91	43.4	18.25	
Ce	48.6	48.67	72.8	36.27	
Nd	very poor reproducibility, no calibration attempted				
Sm	3.74	3.45	4.5	not used	
Eu	1.09	0.9	1.34	not used	
Yb	2.9	2	2.1	3.17	
Lu	poor reproducibility, no calibration attempted				

Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.).*
Methods: XRF *(X-ray Fluorescence Spectrometry);* INA *(Instrumental Neutron Activation).*

Table 7a. *Regression line parameters for calibration of major element volatile-free oxide data determined by X-ray Fluorescence Spectrometry.*

Batch code	Stream sediment sample numbers		SiO_2 a	SiO_2 b	TiO_2 a	TiO_2 b	Al_2O_3 a	Al_2O_3 b	Fe_2O_3 a	Fe_2O_3 b	MnO	MgO a	MgO b	CaO a	CaO b	Na_2O a	Na_2O b	K_2O a	K_2O b	P_2O_5 a	P_2O_5 b
A	330701-836	GGU*	n		n		n		n		n	n		n		n		n		n	
B	330401-668	GGU*	0.996	0.016	0.995	0	0.996	0	0.996	0	n	0.996	0	0.996	0	0.96	0.56	0.996	0	0.996	0
C	330901-921,934-971	GGU	n		n		0.9	1.2	n		n	n		n		0.93	0.15	n		1.02	-0.015
D	381966-382060	GGU	n		n		n		n		n	n		n		n		n		n	
E	380001-303	GGU	n		n		n		n		n	n		n		n		n		0.78	0.03
F1	380401-600	Act	1.044	-1.922	0.979	-0.04	n		n		n	n		0.97	-0.1	0.89	0.34	n		1.1	-0.026
F2	380602-800	Act	1.044	-1.922	0.979	-0.04	n		n		n	n		0.97	-0.1	0.89	0.34	n		1.1	-0.026
F3	380801-381000	Act	1.044	-1.922	0.979	-0.04	n		n		n	n		0.97	-0.1	0.89	0.34	n		1.1	-0.026
F4	381001-149	Act	1.044	-1.922	0.979	-0.04	n		n		n	n		1.07	-0.84	0.89	0.34	n		1.1	-0.026
G	193001-598	Act	n		1.022	-0.06	n		n		n	n		0.95	0.06	0.89	0.34	n		n	
H1,H2	368001-367	GGU	n		n		0.94	0.95	n		n	n		n		1.05	-0.04	n		n	
I1	306001-150,201-251	GGU	n		n		0.95	0.96	n		n	n		n		n		n		n	
I2	306401-548	GGU*	n		n		n		n		n	n		n		n		n		n	
I3	330670-695	GGU*	n		n		n		n		n	n		n		n		n		n	
J1,J2	301701-754,309101-700	GGU*	n		n		n		n		n	n		n		n		n		n	
I4,K1,K2	381742-965	GGU	n		n		n		n		n	n		n		n		n		n	
K3,L2,L3	306301-367, 263124-392	GGU	n		n		n		n		n	n		n		n		n		n	
L1	330001-330340	GGU**	0.996	0.016	0.995	0	0.996	0	0.996	0	n	0.996	0	0.996	0	0.96	0.56	0.996	0	0.996	0
L4,M3	381692-741	GGU	n		n		n		n		n	n		n		n		n		n	
M1,M2	386001-500	GGU	n		0.918	0.02	n		n		n	n		n		1.07	-0.05	n		n	
M4	329501-583	GGU	n		n		n		n		n	n		n		n		n		n	
N1,N2	381401-691	GGU	n		n		n		n		n	n		n		n		n		n	
O1	280002-607	GGU*	n		n		n		n		n	n		n		n		n		n	
O2	280608-281000	GGU	n		n		0.94	0.95	n		n	n		n		0.93	0.15	n		n	
O3	281002-281518	GGU*	n		n		n		n		n	n		n		n		n		n	
O4	281519-835	GGU	n		n		n		n		n	n		n		n		n		n	
O5	281836-282926	GGU	n		n		0.89	1.4	n		n	n		n		n		n		0.91	0.03
P	386701-845	Act	0.98	0.97	1.037	0.02	0.8	2.55	n		n	n		0.96	0.03	0.81	0.58	n		0.83	0.05
UM1	501088-91,93-200,301-328,351-37	Act	0.93	5.21	n		1	0.21	0.97	-0.4	n	1	-0.4	1	-0.12	n		n		n	
UM2	501001-87,92,201-44,376-400	Act	1.02	-0.83	n		1.09	-0.96	1.03	-0.39	n	1	-0.39	1	-0.12	n		n		n	
UM3	501245-300,329-350,401-413	Act	n		n		0.87	1.89	1.03	-0.39	n	1	-0.39	1	-0.12	n		n		n	
UM4	501414-501568	Act	n		n		0.87	1.89	1.03	-0.39	n	1	-0.39	1	-0.12	n		n		n	
UM5,UM6	350710-746,366102-158,386902-930	Act	n		n		0.87	1.89	1.03	-0.39	n	1	-0.39	1	-0.12	n		n		n	
UP1	501601-709,711-743	GGU	n		n		n		n		n	n		n		n		0.98	0	1.07	-0.02
UP2	501710,744-850	GGU	n		n		n		n		n	n		n		0.906	0.09	0.98	0	1.07	-0.02

Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);*

a, b*: parameters in the equation for the regression line y=ax+b used for calibrating measured concentrations to reference concentration levels.*

n: *no correction required. * analysed without standards.** corrected by means of reanalysis (Fig. 12k)*

Table 7b. *Regression line parameters for calibration of trace element data determined mostly by Instrumental Neutron Activation Analysis.*

Batch	Stream sediment		Co		Ce		Hf		La		Sc		Sm		Th		Eu			Yb		U		
code	sample numbers	INA	a	b	a	b	a	b	a	b	a	b	a	b	a	b	INA	a	b	a	b		a	b
A	330701-836	B-C[1]	n		0.75	5.1	n		0.79	3.6	n		0.74	-0.34	0.71	0.9	no data					Risø DNC	n	
B	330401-668	B-C[1]	n		0.74	22.9	n		0.98	7.1	n		1.37	-1.93	0.71	0.9	no data					Risø DNC	n	
C	330901-921,934-971	B-C[1]	n		1.23	-9.27	n		1	-5.4	n		1.21	-1.67	0.71	0.9	no data					B-C INA	0.84	-0.77
D	381966-382060	Act	n		1.18	1.84	n		n		n		1.28	-0.56	n		Act	n		n		Act INA	n	
E	380001-303	Act	1.23	-0.36	1.15	1.44	n		1.1	1.46	n		1.14	0	n		Act	1.33	-0.17	n		Act INA	n	
F1	380401-600	Act	n		n		n		n		n		1.08	0.47	n		Act	1.28	-0.1	n		Act INA	n	
F2	380602-800	Act	n		n		n		n		n		0.51	1.8	n		Act	0.79	0.13	n		Act INA	n	
F3	380801-381000	Act	n		n		n		n		n		n		n		Act	n		n		Act INA	n	
F4	381001-149	Act	n		n		0.86	0.5	n		0.92	-0.93	n		n		Act	n		n		Act INA	n	
G	193001-598	Act	1.15	-0.44	1.42	-5	n		1.14	0.17	n		1.08	0.47	n		Act	1.55	-0.3	1.4	-0.32	Risø DNC	n	
H1,H2	368001-367	Act	1.02	1.8	1.15	1.44	1.2	0.28	1.1	1.46	1.13	0.7	1	1	n		Act	1.28	0	1.15	0.13	Act INA	n	
I1	306001-150,201-251	Act	1.13	0	1.15	1.44	1.2	0.28	1.1	1.46	1.13	0.7	1	1	n		Act	1.28	0	1.15	0.13	Risø DNC	n	
I2	306401-548	Act	1.13	0	1.15	1.44	1.2	0.28	1.1	1.46	1.13	0.7	1	1	n		Act	1.28	0	1.15	0.13	Risø DNC	n	
I3	330670-695	B-C[1]	n		0.74	22.9	n		0.98	7.1	n		1.37	-1.93	0.71	0.9	no data					Risø DNC	n	
J1	301701-754	Act	n		n		n		n		n		1.67	-1.9	n		Act	n		n		Risø DNC	n	
J2	309101-700	Act	n		n		n		n		n		1.67	-1.9	n		Act	n		n		Risø DNC	n	
K1	381742-900	Act	n		n		0.8	0.2	n		0.82	0	n		n		Act	0.8	0.1	0.66	0.65	Act INA	n	
K2	381901-965	Act	n		1.18	1.84	n		n		n		1.28	-0.56	n		Act	n		n		Act INA	n	
K3,L2,L3	306301-367, 263124-392	Act	n		n		n		n		n		n		n		Act	n		1.23	-0.17	Risø DNC	n	
L1	330001-330340	Act	n		0.76	6.2	n		n		n		0.69	0.66	n		Act	0.79	0.13	n	0.61	Act INA	n	
L4,M3	381692-741	Act	n		n		0.9	0.6	n		n		n		n		Act	n		n	0.33	Act INA	n	
M1,M2	386001-500	Act	1.06	-1.25	n		n		n		n		n		n		Act	n		n		Act INA	n	
M4	329501-583	Act	n		n		n		n		n		n		n		Act	n		n	-0.17	Act INA	n	
N1	381401-550	Act	n		n		0.99	-1.3	n		0.9	-0.23	n		n		Act	n		n	0.22	Act INA	n	
N2	381551-691	Act	n		n		1.05	1	n		n		n		n		Act	n		n	0.13	Act INA	n	
O1- O5	280002-282926	Act*	1.13		1.15	1.44	1.2	0.28	1.1	1.46	1.13	0.7	1	1	n		Act*	1.28	0	1.15	0.13	Risø DNC	n	
P	386701-845	Act	1.02	1.7	1.14	0.65	1.3	-0.5	1.14	0.17	n		1.08	0.47	n		Act	1	0.2	1.4	-0.32	Act INA	n	
A,B,C	25 selected	Act	n		1.18	1.84	n		n		n		1.28	-0.56	n		Act	0.79	0.28	0.98	0.04	Act INA	n	
UM1	501088-91,93-200,301-328,351-375	Act	n		n		1.06	0.47	0.96	2.6	n		0.53	1.45	n		Act	n		1.13	0.17	Act INA	n	
UM2	501001-87,92,201-44,376-400	Act	n		n		1.06	0.47	0.96	2.6	1.09	0.46	0.87	0.85	n		Act	n		1.13	0.17	Act INA	n	
UM3	501245-300,329-350,401-413	Act	n		0.65	12	1.06	0.47	0.96	2.6	n		0.63	0.97	0.73	0.2	Act	0.92	-0.16	n		Act INA	n	
UM4	501414-501568	Act	1.1	0.5	n		1.06	0.47	1.176	1.5	n		n		n		Act	n		1.34	-0.24	Act INA	n	
UM5	350710-746,366102-158	Act	1.1	0.5	n		n		0.96	-0.6	n		0.61	0.93	n		Act	n		1.6	-1.27	Act INA	n	
UM6	386902,4-6,8,11-12,15,21-22,24,30	Act	1.06	0.8	1.2	-3.6	n		n		n		0.8	0.96	n		Act	n		n		Act INA	n	
UM7	501461,73,531	Act	1.1	0.5	1.57	-0.9	1.19	0.8	1.176	1.5	n		0.82	1.275	1.09	0.7	Act	n		1.34	-0.24	Act INA	n	
UP1	501601-709,711-743	Act	n		n		1.14	1.8	1.14	0.2	n		n		n		Act	n		1.6	-1.02	Act INA	n	
UP2	501710,744-850	Act	1.26	-3.3	n		1.14	1.8	1.14	0.2	1.13	-0.3	n		n		Act	n		1.296	0.156	Act INA	n	
UP3	501746,51,53-54,57,73-74,86,92	Act	1.26	-3.3	n		1.4	0	n		1.13	-0.3	n		n		Act	n		1.296	0.156	Act INA	n	

Laboratories: Act *(Activation Laboratories Ltd.);* B-C *(Bondar-Clegg and Co. Ltd.);* Risø *(Risø National Laboratory).*

Methods: INA *(Instrumental Neutron Activation);* DNC *(Delayed Neutron Counting)*

a, b: *parameters in the equation for the regression line y=ax+b used for calibrating measured concentrations to reference concentration levels.*
n: *no calibration required;*

[1] Calibrated via 25 samples analysed at Act INA together with standards; * same calibration as batch I1.

Table 7c. *Regression line parameters for calibration of trace element data determined mostly by X-ray Fluorescence Spectrometry.*

Batch code	Stream sediment sample numbers		Ba a	Ba b	Cr a	Cr b		Ni a	Ni b	Sr a	Sr b		V a	V b		Rb a	Rb b		Zn a	Zn b		Zr a	Zr b
A	330701-836	GGU XRF	imp		imp		GGU XRF	imp		imp		GGU XRF	imp		GGU XRF	1.46	-12		imp			imp	
B	330401-668	GGU XRF	imp		imp		GGU XRF	0.99	-15	1.24	-24	GGU XRF	0.86	18	GGU XRF	1.46	-12		0.77	9		imp	
C	330901-921,934-971	Act XRF	0.93	28	n		Act XRF	n		1.05	-1	Act XRF	n		Act XRF	n			n			n	
D	381966-382060	Act XRF	1.22	-24	n		Act XRF	0.85	9	n		Act XRF	1.056	-20	Act XRF	n			n			n	
E	380001-303	Act XRF	n		1	-50	Act XRF	n		n		Act XRF	n		Act XRF	n			n			n	
F1	380401-600	Act XRF	1.22	-100	1	35	Act XRF	n		1.09	-1	Act XRF	1.36	-13	Act XRF	n			1.03	-7.5		1.14	-9
F2	380602-800	Act XRF	1.22	-100	1	35	Act XRF	n		1.09	-1	Act XRF	1.36	-13	Act XRF	n			1.03	-7.5		1.14	-9
F3	380801-381000	Act XRF	1.22	-100	1	35	Act XRF	n		1.09	-1	Act XRF	1.36	-13	Act XRF	n			1.03	-7.5		1.14	-9
F4	381001-149	Act XRF	1.22	-100	1	35	Act XRF	n		1.07	-8	Act XRF	1.36	-13	Act XRF	n			1.03	-7.5		1.14	-9
G	193001-598	Act XRF	1.28	-71	1	25	Act XRF	n		1.07	-8	Act XRF	0.92	31	Act XRF	n			1.13	-19		n	
H1,H2	368001-367	Act XRF	n		1	-50	Act XRF	n		n		Act XRF	n		Act XRF	n			n			n	
I1	306001-150,201-251	Act XRF	n		1	-50	Act XRF	n		n		Act XRF	n		Act XRF	n			n			n	
I2	306401-548	Act XRF	n		1	-50	Act XRF	n		n		Act XRF	n		Act XRF	n			n			n	
I3	330670-695	GGU XRF	imp		imp		GGU XRF	imp		imp		GGU XRF	imp		GGU XRF	1.46	-12		imp			imp	
J1, J2	301701-754,309101-700	GGUXRF[1]	1.25	-180	1.05	29	GGUXRF[1]	1.08	-23	1.04	-16	GGUXRF[1]	0.72	29	Risø XRF[1]	0.46	20		1.25	-8		0.87	31
I4,K1,K2	381742-965	Act XRF	1.216	-24	1	15	Act XRF	0.85	9	n		Act XRF	1.056	-20	Act XRF	n			n			n	
K3,L2a,L3	306301-367,263124-200,263278-298	GGU XRF	0.83	24	n		GGU XRF	0.9	27	1.37	-76	GGU XRF	1.12	-20	GGU XRF	1.46	-12		0.72	14		1.06	5
L2b	263201-276,263320-386	GGU XRF	0.83	24	n		GGU XRF	0.9	27	1.35	-98	GGU XRF	1.12	-20	GGU XRF	1.46	-12		0.72	14		1.06	5
L1	330001-330340	GGU XRF	imp		imp		GGU XRF	0.99	-15	1.235	-24	GGU XRF	0.86	18	GGU XRF	1.46	-12		0.77	9		imp	
L1							Act ICP	1.14	-11	1.3	-18	Act ICP	1.05	6	Act ICP	no data			0.99	-6		no data	
L4,M2,M3	381692-741,386171-500	Act XRF	0.93	28	1.3	-36	Act XRF	1.05	0	1.05	-1	Act XRF	n		Act XRF	n			n			n	
M1	386001-170	Act XRF	1.17	-68	1.3	-36	Act XRF	n		n		Act XRF	n		Act XRF	n			n			n	
M4	329501-583	GGU XRF	0.83	24			GGU XRF	0.9	27	1.37	-76	GGU XRF	1.12	-20	GGU XRF	1.46	-12		0.72	14		1.06	5
N1,N2	381401-691	Act XRF	1.216	-24	n		Act XRF	0.85	9	1.07	-8	Act XRF	1.05	-20	Act XRF	n			n			n	
O1-O4	280002-281835	Act INA[2]	0.96	39	0.99	-10	Risø XRF[2]	0.84	8	0.93	34	GGU XRF[2]	1.02	31	Risø XRF[2]	0.6	10		n			0.96	41
O5	281836-282926	Act INA[2]	0.96	39	0.99	-10	Risø XRF[2]	0.84	8	0.93	34	GGU XRF[2]	n		Risø XRF[2]	0.6	10		n			0.96	41
P	386701-845	Act XRF	1.197	-46	n		Act XRF	1.05	2	1.13	-4	Act XRF	1.36	-13	Act XRF	n			1.03	-7.5		1.14	-9
Jx	26 selected	Act XRF	1.09	0	1.4	-18	Act XRF	1.08	2	n		Act XRF	n		Act XRF	n			n			n	
Ox	27 selected+CANMET standards	Act XRF	n		1	15	Act XRF	0.94	16	n		Act XRF	n		Act XRF	n			0.98	-7.2		n	
UM1	501088-91,93-200,301-328,351-375	Act INA	n		n		Act ICP	n		1.22	-17	Act ICP	1.03	0.8	Act INA	n		Act ICP	1.04	-6.7		no data	
UM2	501001-87,92,201-44,376-400	Act INA	n		n		Act ICP	n		1.22	-17	Act ICP	1.03	0.8	Act INA	n		Act ICP	1.21	-8		no data	
UM3	501245-300,329-350,401-413	Act INA	n		n		Act ICP	n		1.22	-17	Act ICP	n		Act INA	n		Act ICP	1.21	-8		no data	
UM4	501414-501568	Act INA	n		n		Act ICP	n		1.22	-17	Act ICP	n		Act INA	n		Act ICP	1.21	-8		no data	
UM5	350710-746,366102-158	Act INA	n		n		Act ICP	n		1.06	2	Act ICP	1.03	3	Act INA	n		Act ICP	1.11	-9.6		no data	
UM6	386902,4-6,8,11-12,15,21-22,24,30	Act INA	n		n		Act ICP	n		1.18	-7	Act ICP	1.03	3	Act INA	n		Act ICP	1.11	-9.6		no data	
UM7	501461,73,531	Act INA	n		n		no data					no data			Act INA	invalid		no data				no data	
UP1	501601-709,711-743	Act INA	n		n		Act ICP	n		1.2	-24	Act ICP	1.03	3	Act INA	n		Act ICP	1.11	-9.6	GGU XRF	n	
UP2	501710,744-850	Act INA	n		n		Act ICP	n		1.2	-24	Act ICP	1.03	3	Act INA	n		Act ICP	1.11	-9.6	GGU XRF	n	
UP3	501746,51,53-54,57,73-74,86,92	Act INA	n		n		no data					no data			Act INA	n		no data				no data	

Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);* Risø *(Risø National Laboratory);*
Methods: XRF (X-ray Fluorescence Spectrometry); INA (Instrumental Neutron Activation);
ICP *(Inductively Coupled Plasma Emission Spectrometry);* AAS *(Atomic Absorption Spectrometry)*
a, b: *parameters in the equation for the regression line y=ax+b used for calibrating measured concentrations to reference concentration levels.*
n: *no calibration required;* imp: *calibration impossible.*
[1] Calibrated via 26 samples analysed at Act XRF together with standards; [2] Calibrated via 27 samples analysed by Act XRF together with standards

Table 7c *(continued)*

Batch code		Nb a	Nb b		Y a	Y b		Ga a	Ga b		Cu a	Cu b
A	GGU XRF	imp		GGU XRF	imp		no data			GGU AAS	0.79	-1
B	GGU XRF	imp		GGU XRF	imp		no data			GGU AAS	0.79	-1
C	Act XRF	n		Act XRF	n		Act XRF	n		Act XRF	n	
D	Act XRF	n		Act XRF	n		Act XRF	n		GGU AAS	0.79	-1
E	Act XRF	n		Act XRF	n		Act XRF	n		Act XRF	n	
F1	Act XRF	1	-2	Act XRF	1	-1	Act XRF	n		Act XRF	1.08	-7
F2	Act XRF	1	-2	Act XRF	1	-1	Act XRF	1	2	Act XRF	1.08	-7
F3	Act XRF	1	-2	Act XRF	1	-1	Act XRF	1	2	Act XRF	1.08	-7
F4	Act XRF	1	-2	Act XRF	1	-1	Act XRF	1	2	Act XRF	1.08	-7
G	Act XRF	n		Act XRF	1	1	Act XRF	1	-1	Act XRF	n	
H1,H2	Act XRF	n		Act XRF	n		Act XRF	n		Act XRF	n	
I1	Act XRF	n		Act XRF	n		Act XRF	n		Act XRF	n	
I2	Act XRF	n		Act XRF	n		Act XRF	n		Act XRF	n	
I3	GGU XRF	imp		GGU XRF	imp		no data			GGU AAS	0.79	-1
J1, J2	Risø XRF[1]	0.8	-2	Risø XRF[1]	0.32	12	Risø XRF[1]	1	12	Risø XRF[1]	1.23	11
I4,K1,K2	Act XRF	n		Act XRF	n		Act XRF	n		GGU AAS	0.79	-1
K3,L2a,L3	Risø XRF	imp		Risø XRF	imp		Risø XRF	imp		GGU AAS	0.79	-1
L2b	Risø XRF	imp		Risø XRF	imp		Risø XRF	imp		GGU AAS	0.79	-1
L1	GGU XRF	imp		Act ICP	n		no data			Act ICP	0.86	2
L1	no data											
L4,M2,M3	Act XRF	n		Act XRF	n		Act XRF	n		Act XRF	n	
M1	Act XRF	n		Act XRF	n		Act XRF	n		Act XRF	n	
M4	GGU XRF	imp		GGU XRF	imp		no data			GGU AAS	0.79	-1
N1,N2	Act XRF	n		Act XRF	n		Act XRF	1	-2	GGU AAS	0.79	-1
O1-O4	Risø XRF[2]	0.76	2.2	Risø XRF[2]	0.7	8.9	Risø XRF[2]	n		Risø XRF[2]	0.71	3
O5	Risø XRF[2]	0.76	2.2	Risø XRF[2]	0.7	8.9	Risø XRF[2]	n		Risø XRF[2]	0.71	3
P	Act XRF		-2	Act XRF	1	5	Act XRF	n		Act XRF	1.06	-13
Jx	Act XRF	n		Act XRF	n		Act XRF	n		Act XRF	n	
Ox	Act XRF	n		Act XRF	n		Act XRF	n		Act XRF	n	
UM1	no data			Act ICP	1.08	2.6	no data			Act ICP	0.86	-0.4
UM2	no data			Act ICP	n		no data			Act ICP	0.86	-0.4
UM3	no data			Act ICP	0.8	3	no data			Act ICP	0.86	-0.4
UM4	no data			Act ICP	n		no data			Act ICP	0.86	-0.4
UM5	no data			Act ICP	0.8	2	no data			Act ICP	0.86	-0.4
UM6	no data			Act ICP	n		no data			Act ICP	0.86	-0.4
UM7	no data			no data			no data			no data		
UP1	no data			Act ICP	n		no data			Act ICP	0.86	-0.4
UP2	no data			Act ICP	n		no data			Act ICP	0.86	-0.4
UP3	no data			no data			no data			no data		

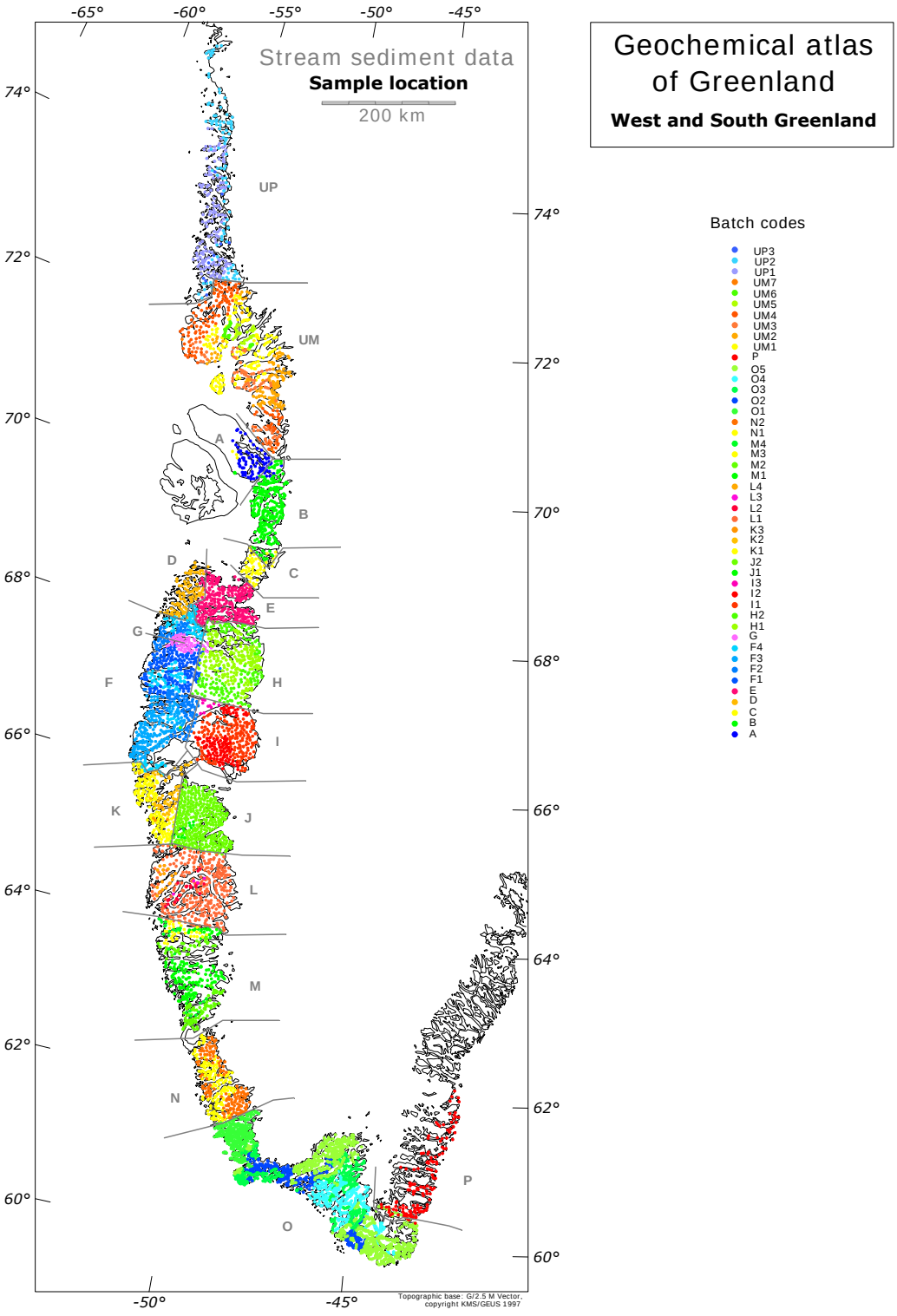


Fig. 1. *Map of sample location. Colouring reflect batches in samples as they have been submitted for analysis. The letter in the batch code refers to the sample area.*

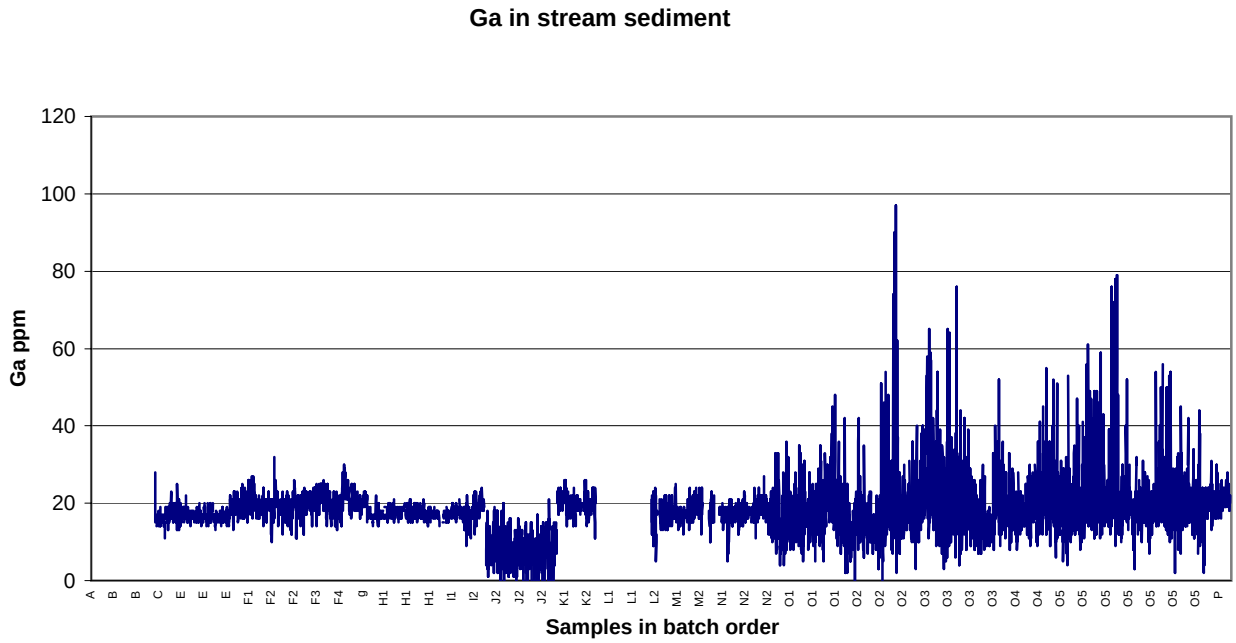


Figure 2a. *Variation in Ga concentrations of stream sediment. Batch J2 is clearly biased towards low concentrations. Samples are analysed by Risø XRF (batch J1, J2, O1 to O5) and by Act XRF (remaining batches).*

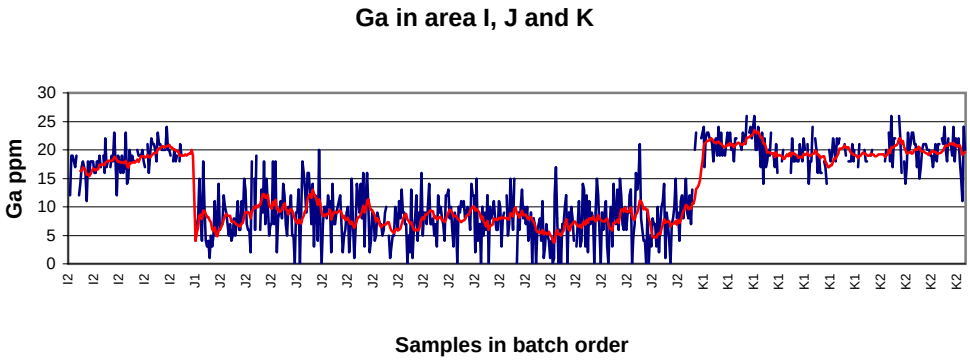


Figure 2b. *Enlargement of Fig. 2a around batch J1 and J2. Red line is moving average of 10 data points.*

Median for batch J1 and J2: 8 ppm
Median for batch K1 and K2: 20 ppm

Calibration of Risø XRF data for batch J1 and J2: y = x + 12

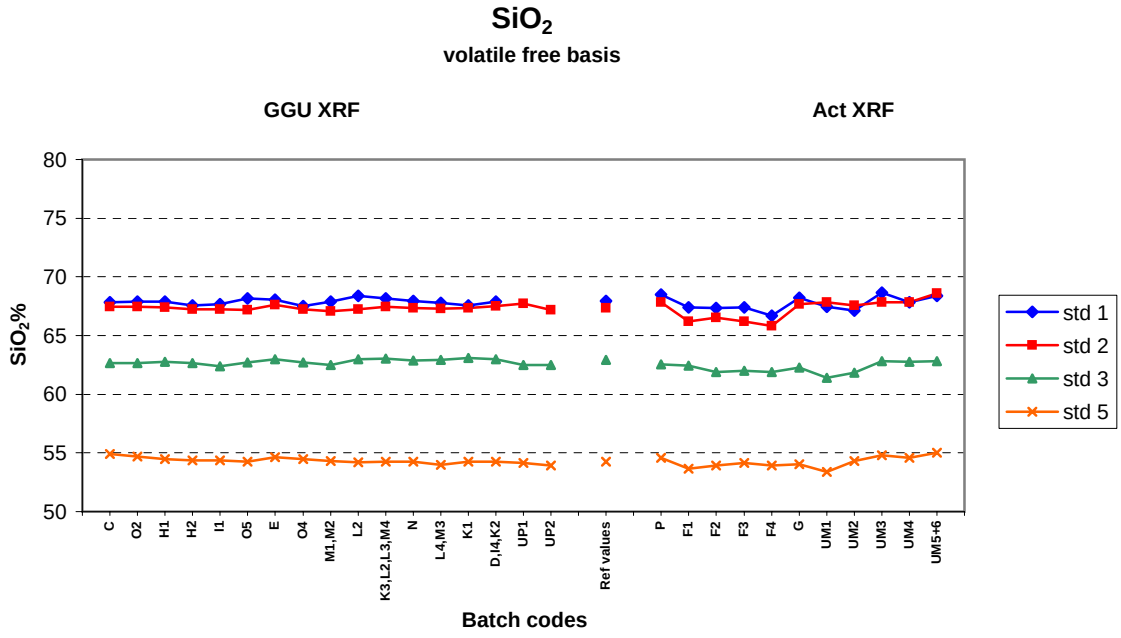


Figure 12a

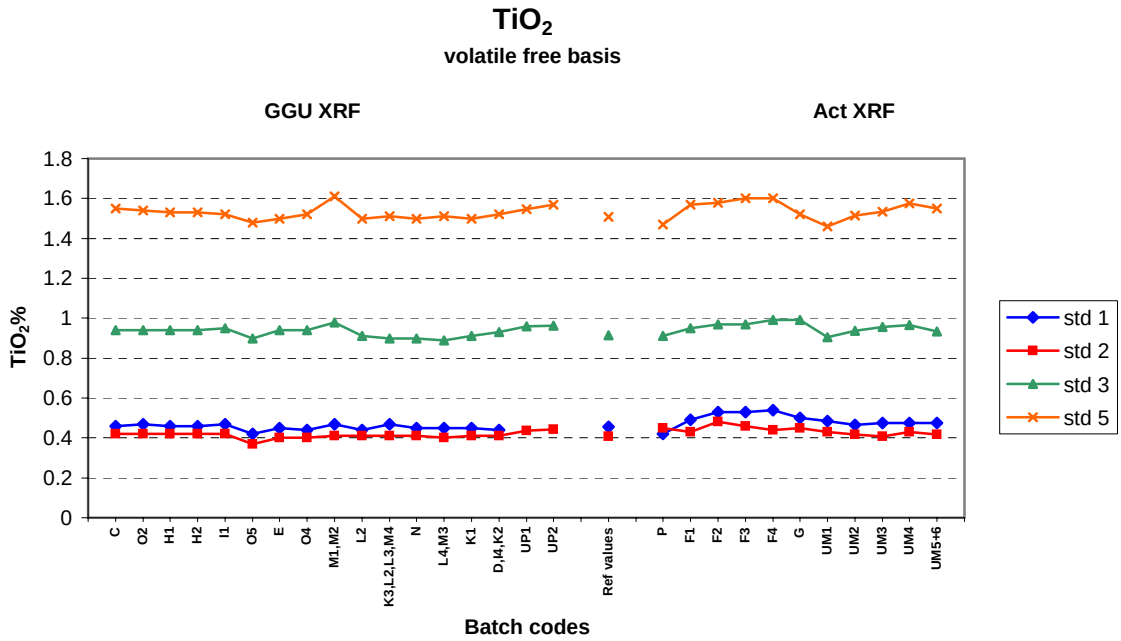


Figure 12b

Figure 12a-j. *Variability of major element data selected for the atlas as monitored by standards.*
Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);*
Methods: XRF *(X-ray Fluorescence Spectrometry).*
Ref values: reference values (Table 6).

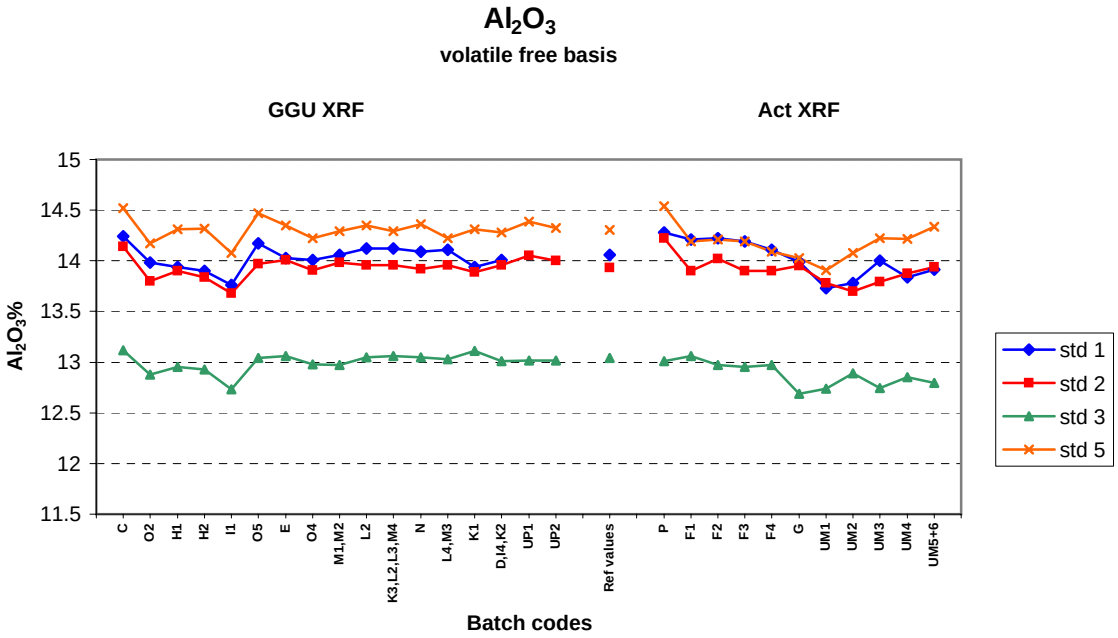


Figure 12c

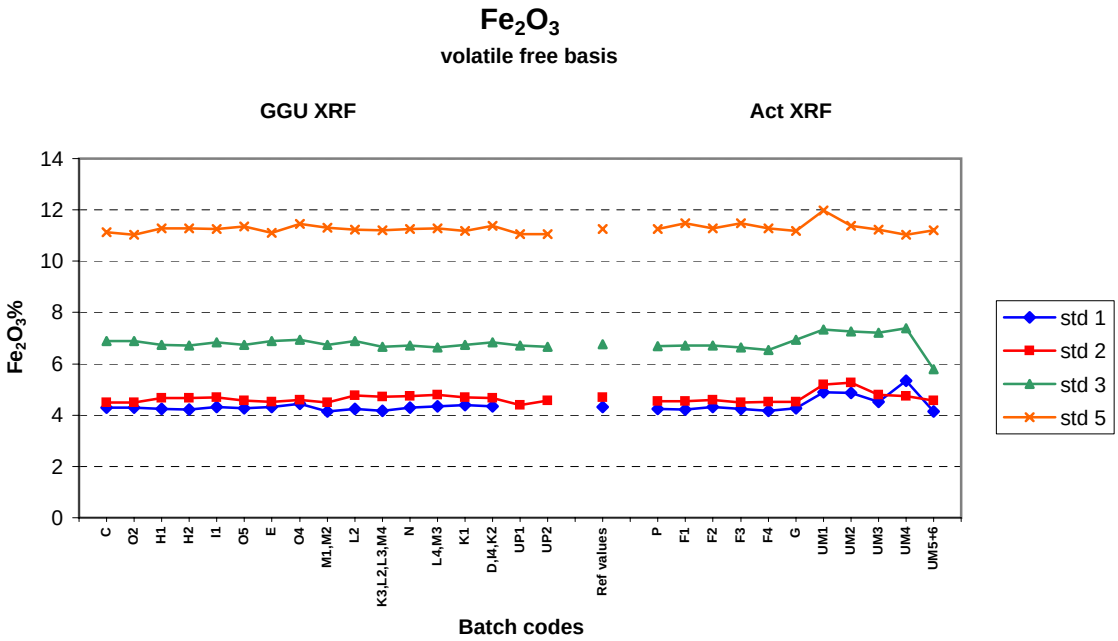


Figure 12d

Figure 12a-j. *Variability of major element data selected for the atlas as monitored by standards.*
Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);*
Methods: XRF *(X-ray Fluorescence Spectrometry).*
Ref values: reference values (Table 6).

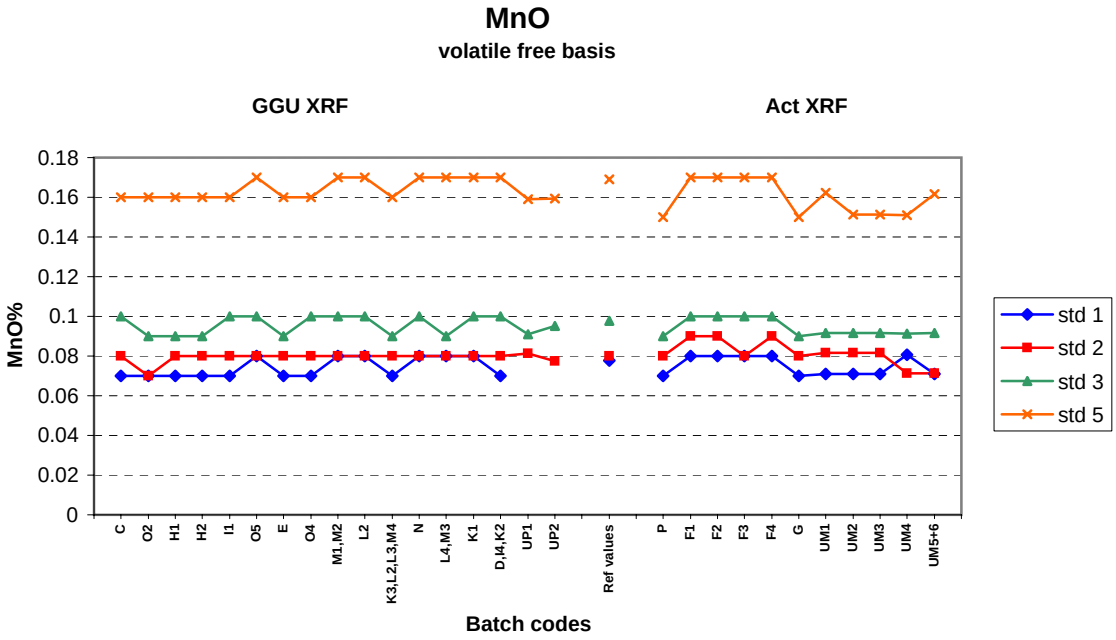


Figure 12e

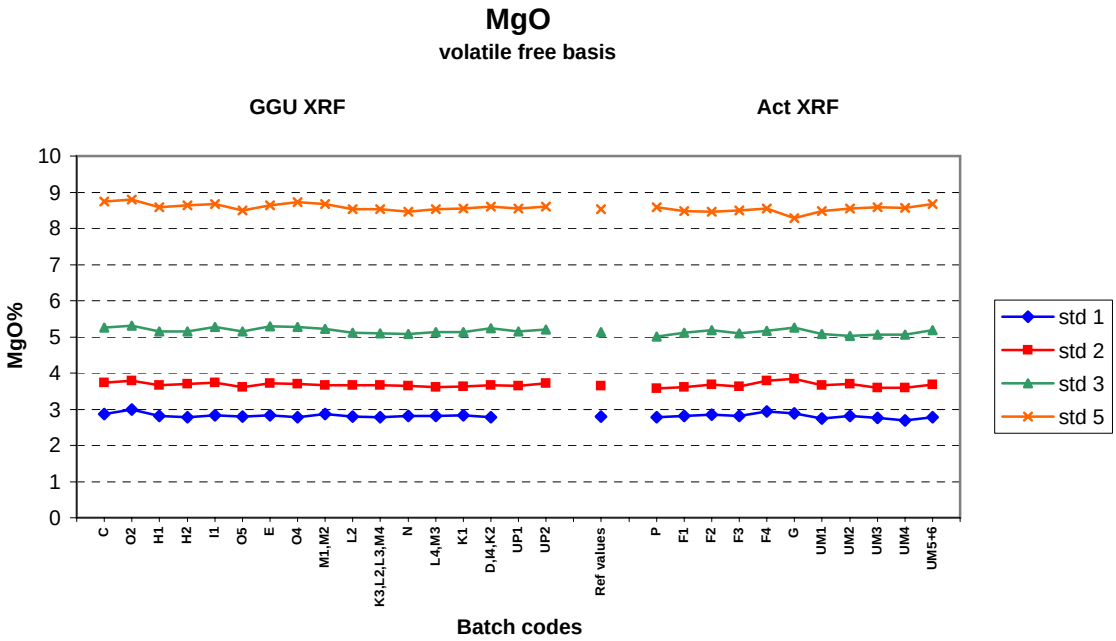


Figure 12f

Figure 12a-j. *Variability of major element data selected for the atlas as monitored by standards.*
Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);*
Methods: XRF *(X-ray Fluorescence Spectrometry).*
Ref values: reference values (Table 6).

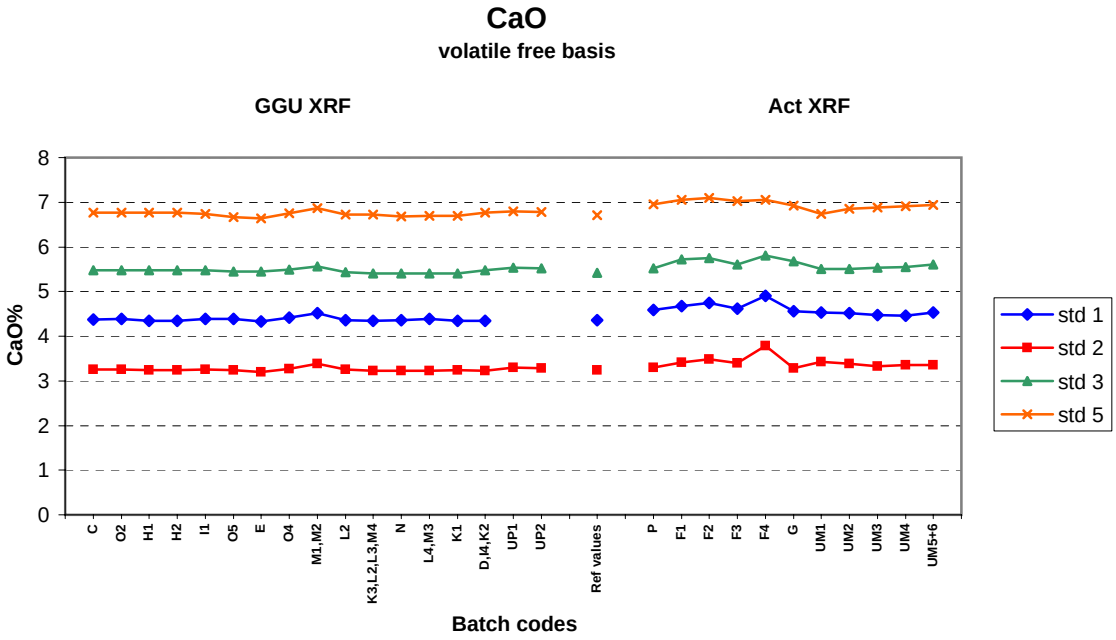


Figure 12g

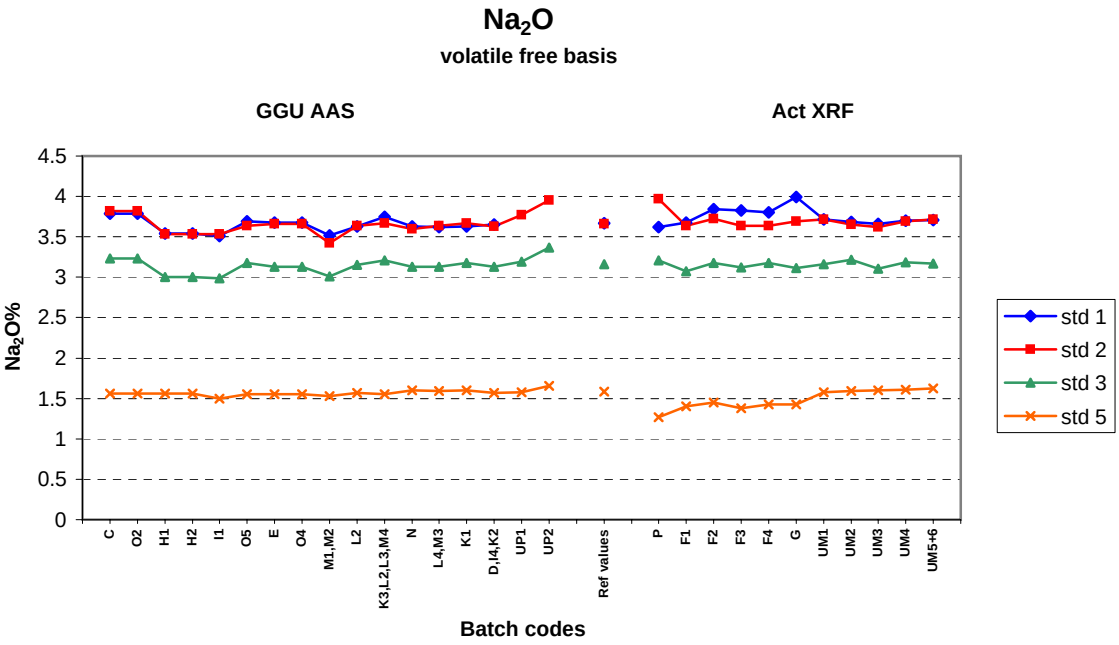


Figure 12h

Figure 12a-j. *Variability of major element data selected for the atlas as monitored by standards.*
Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);*
Methods: XRF *(X-ray Fluorescence Spectrometry);* AAS *(Atomic Absorption Spectrometry).*
Ref values: reference values (Table 6).

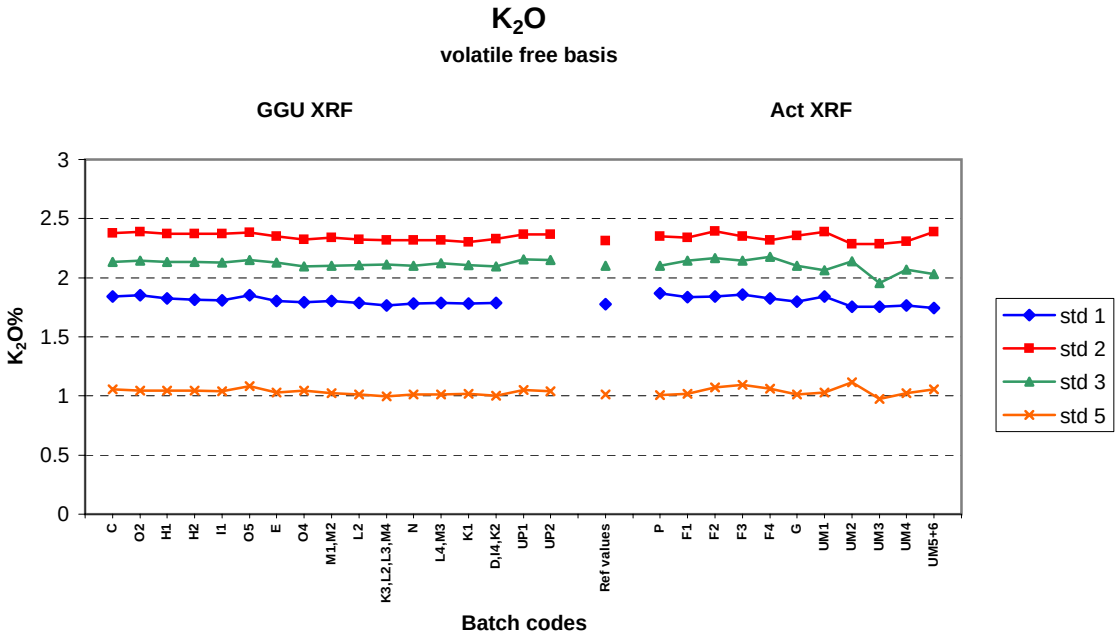


Figure 12i

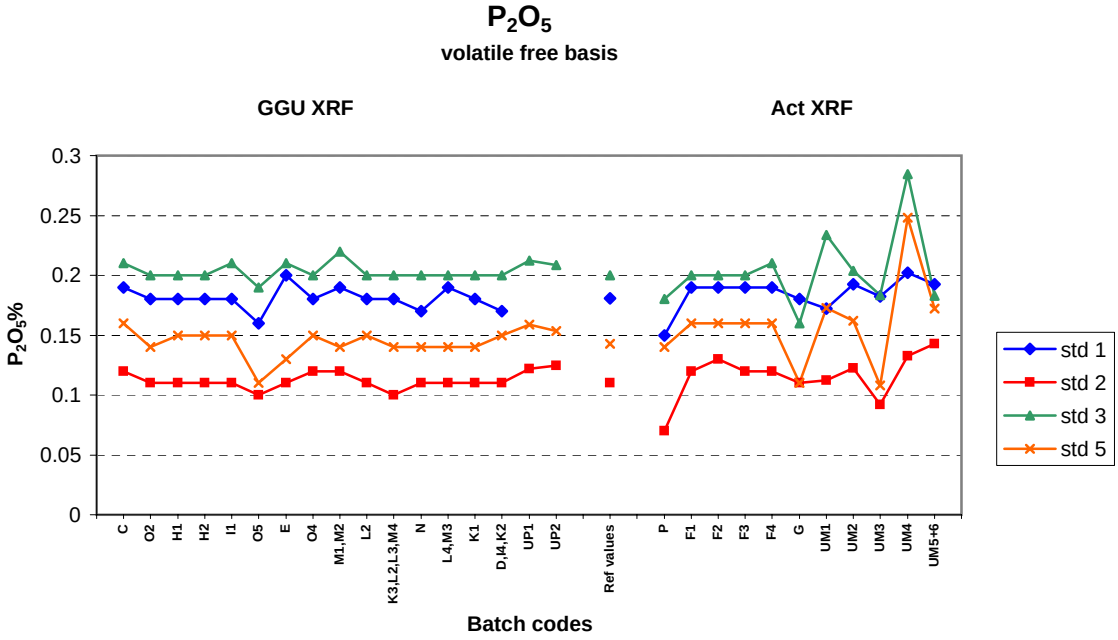


Figure 12j

Figure 12a-j. *Variability of major element data selected for the atlas as monitored by standards.*
Laboratories: GGU *(Geological Survey of Greenland);* Act *(Activation Laboratories Ltd.);*
Methods: XRF *(X-ray Fluorescence Spectrometry).*
Ref values: reference values (Table 6).

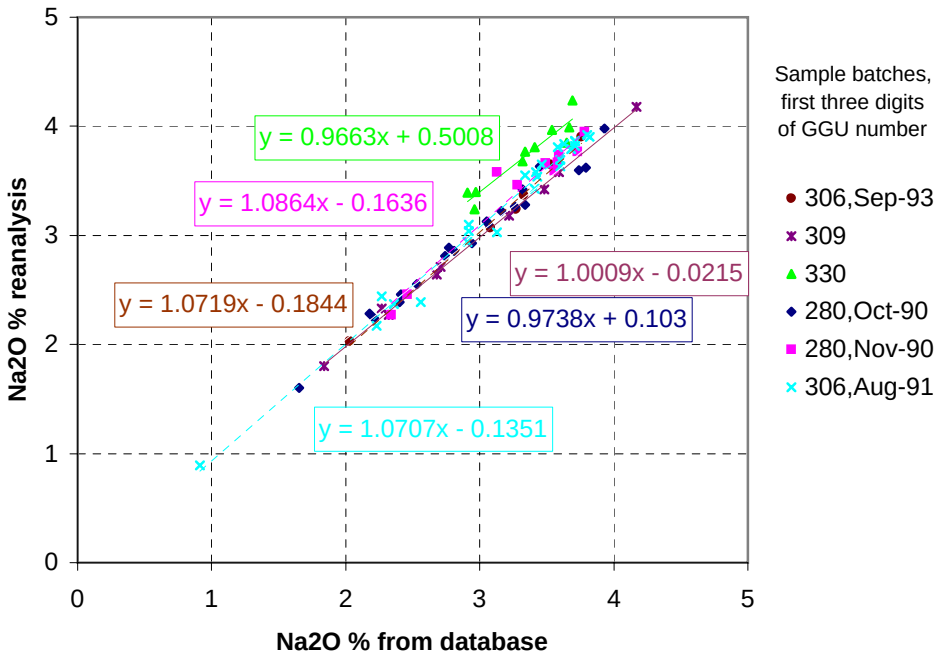


Figure 12k

Figure 12k. *Variability of analytical data for Na_2O in batches analysed before the introduction of standards.*
Laboratory: GGU *(Geological Survey of Greenland)*
Method: AAS *(Atomic Absorption Spectrometry).*

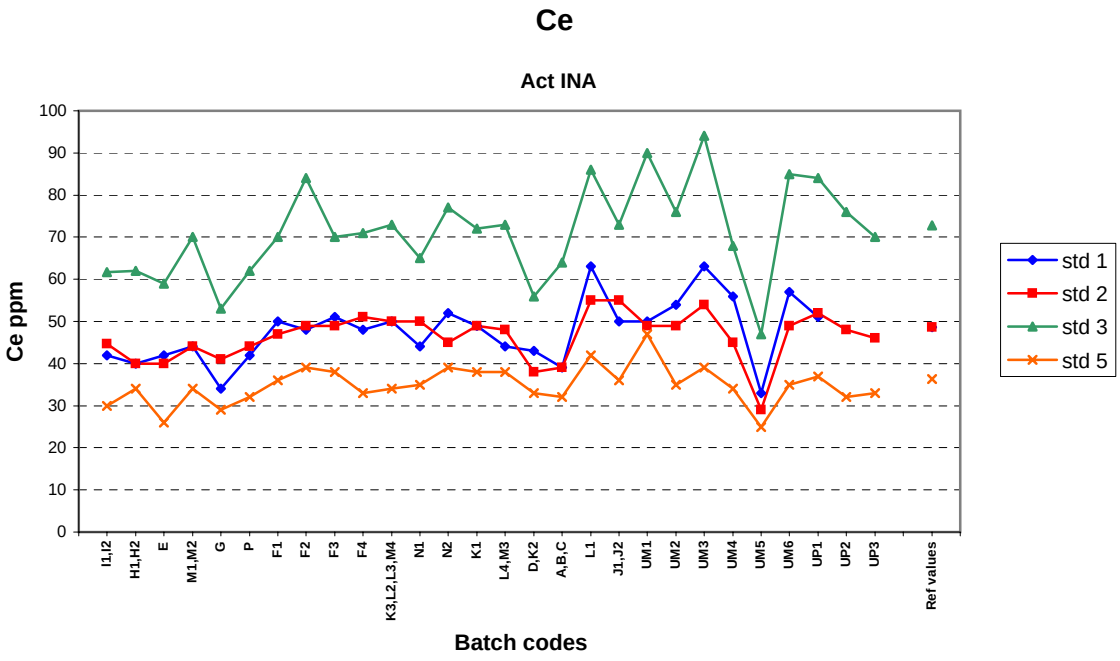


Figure 13a

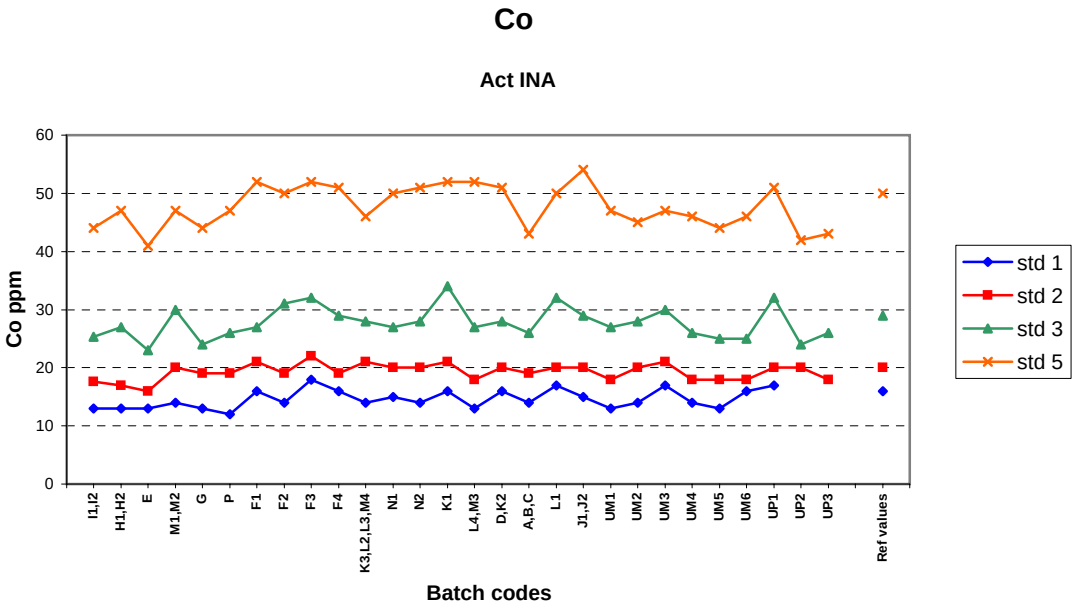


Figure 13b

Figure 13a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratory: Act *(Activation Laboratories Ltd.).*
Method: INA *(Instrumental Neutron Activation).*
Ref values: reference values (Table 6).

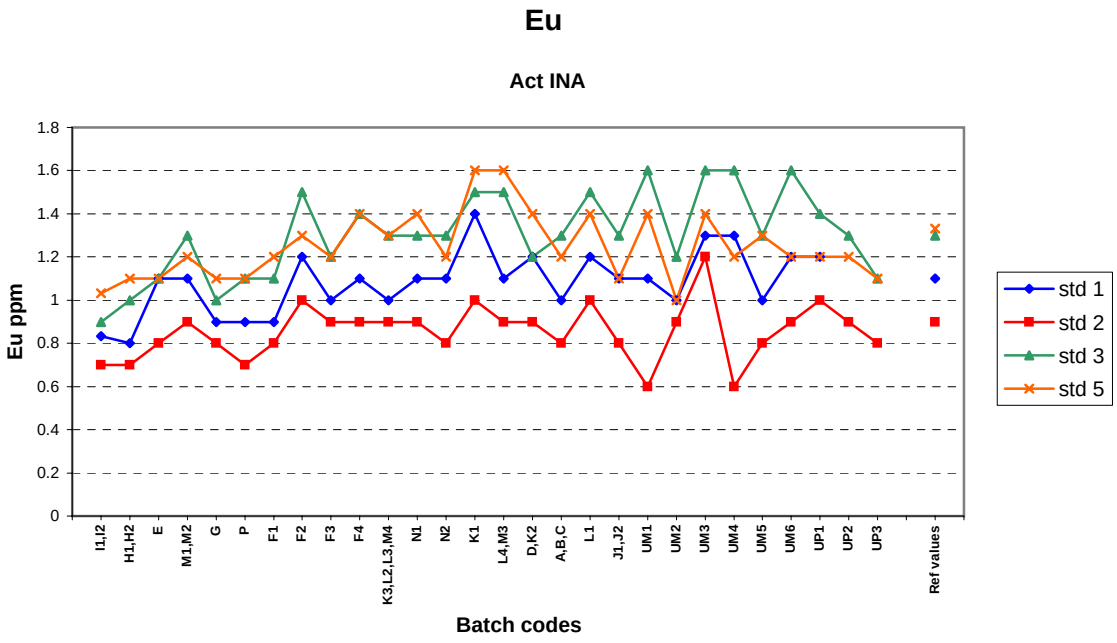


Figure 13c

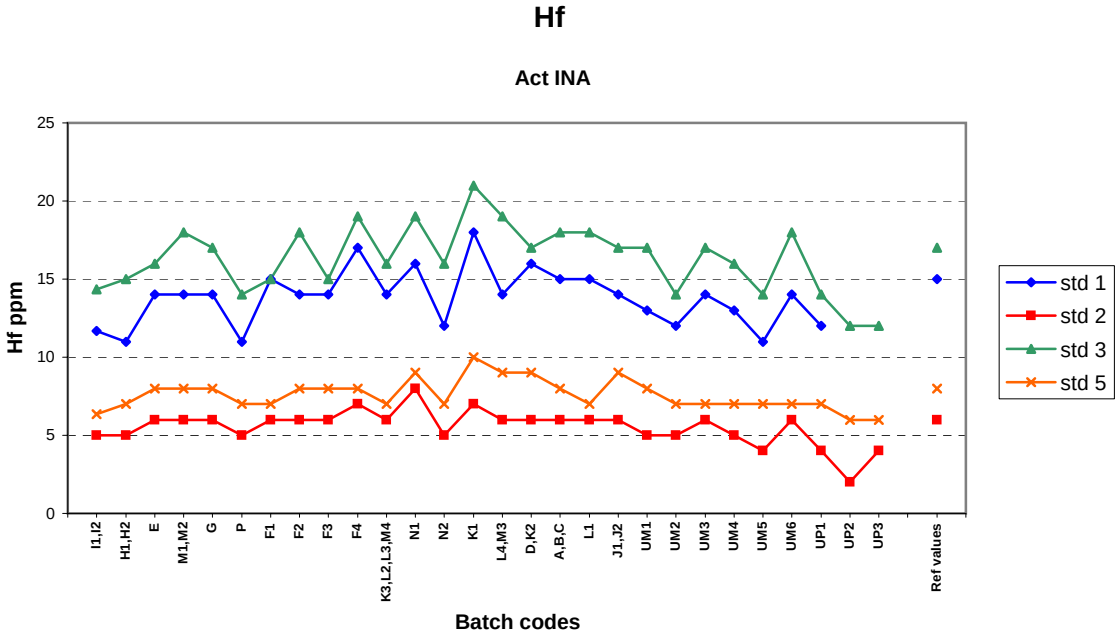


Figure 13d

Figure 13a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratory: Act *(Activation Laboratories Ltd.).*
Method: INA *(Instrumental Neutron Activation).*
Ref values: reference values (Table 6).

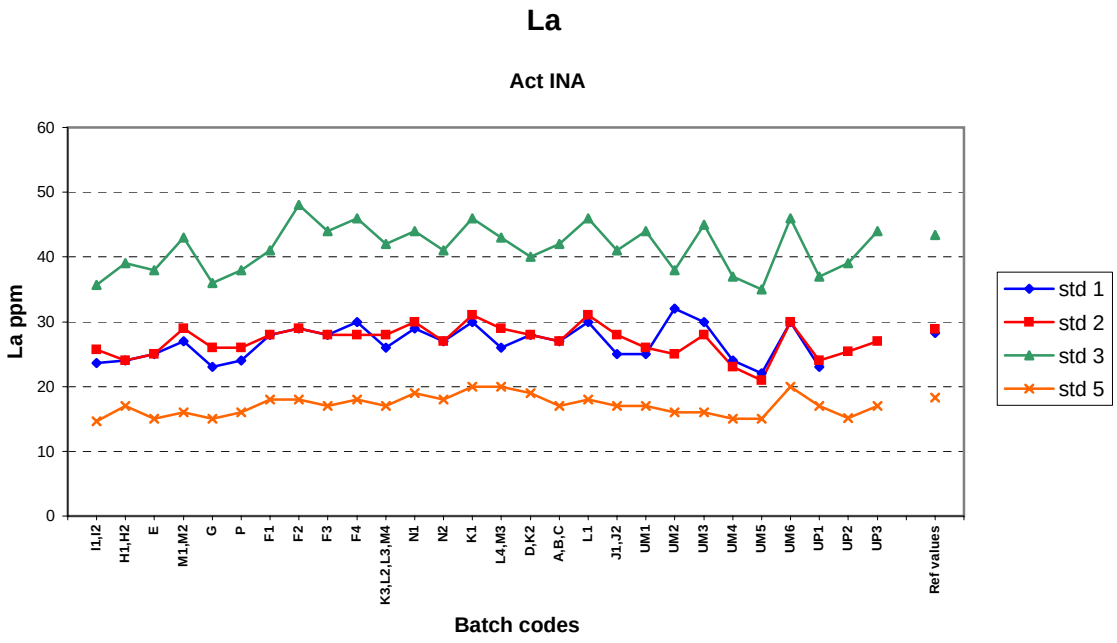


Figure 13e

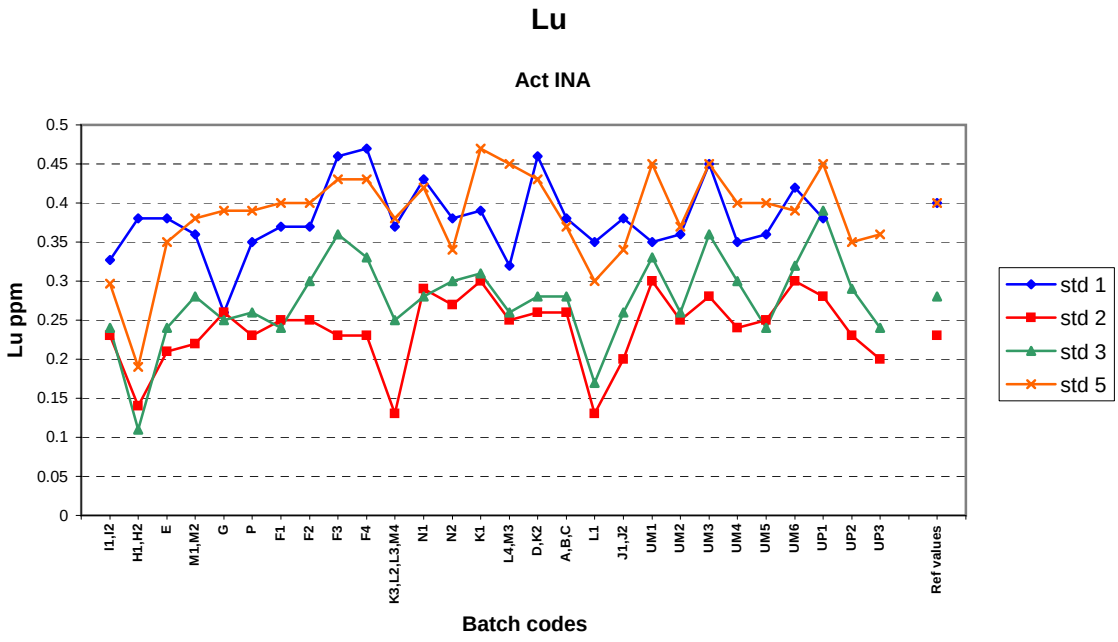


Figure 13f

Figure 13a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratory: Act *(Activation Laboratories Ltd.).*
Method: INA *(Instrumental Neutron Activation).*
Ref values: reference values (Table 6).

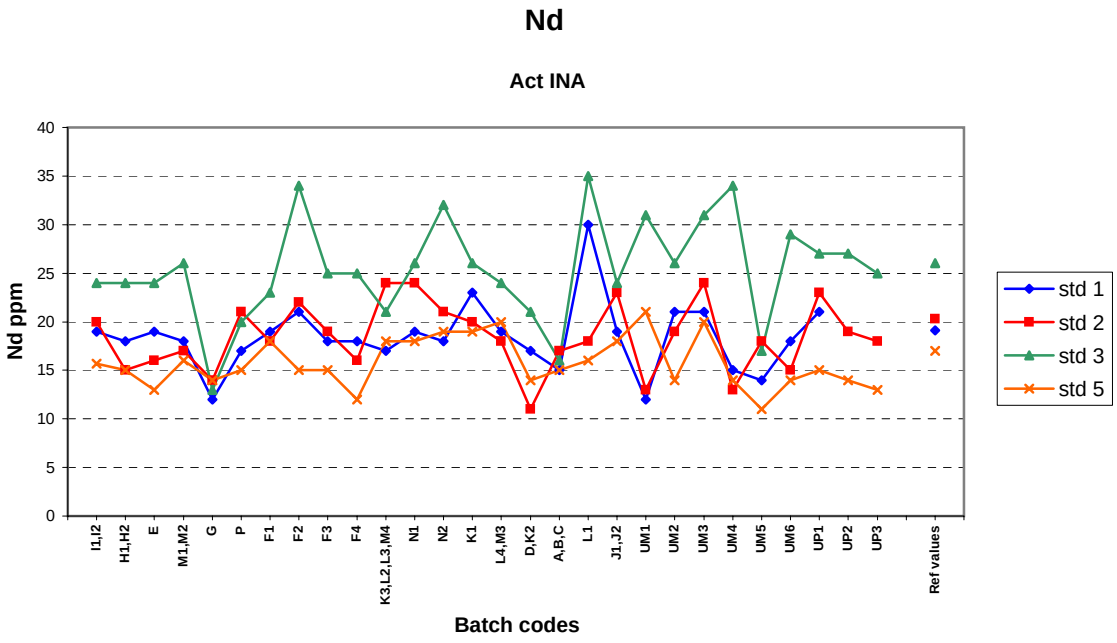


Figure 13g

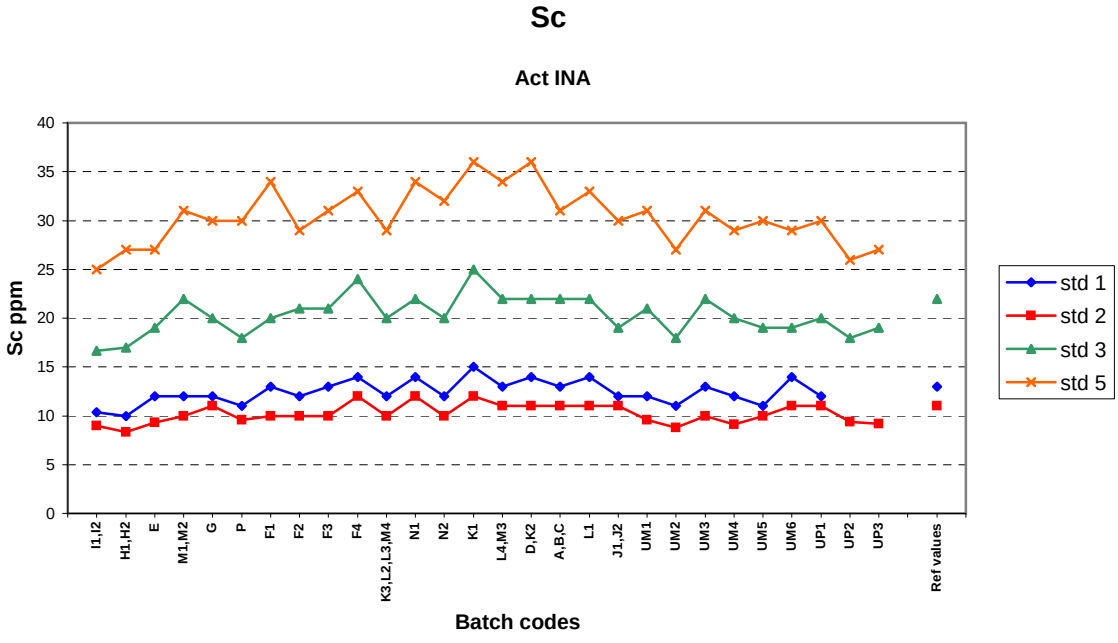


Figure 13h

Figure 13a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratory: Act *(Activation Laboratories Ltd.).*
Method: INA *(Instrumental Neutron Activation).*
Ref values: reference values (Table 6).

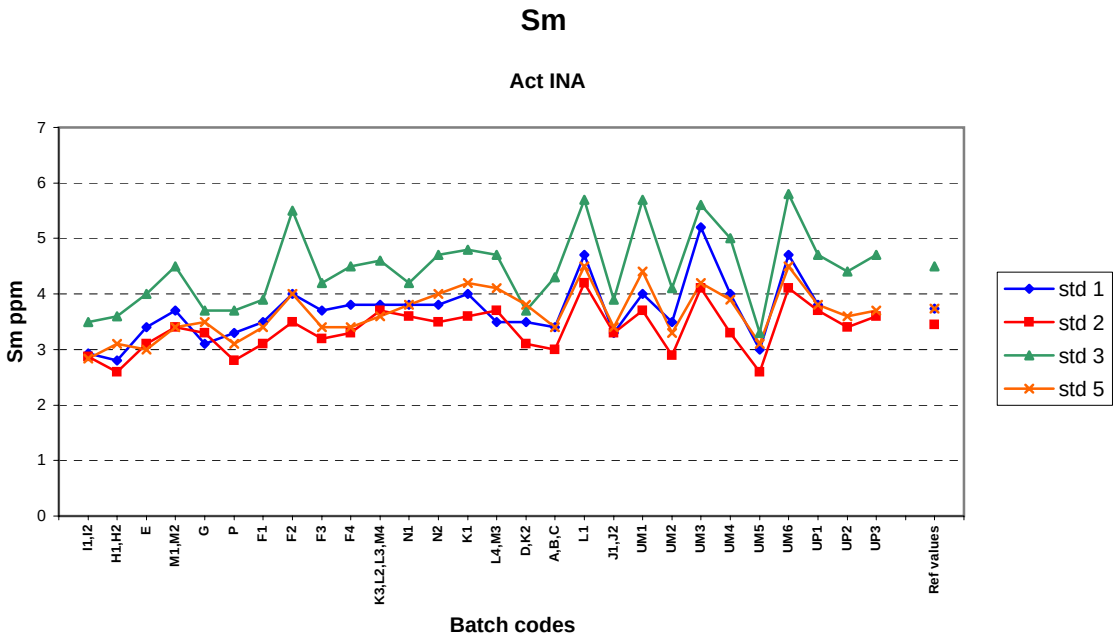


Figure 13i

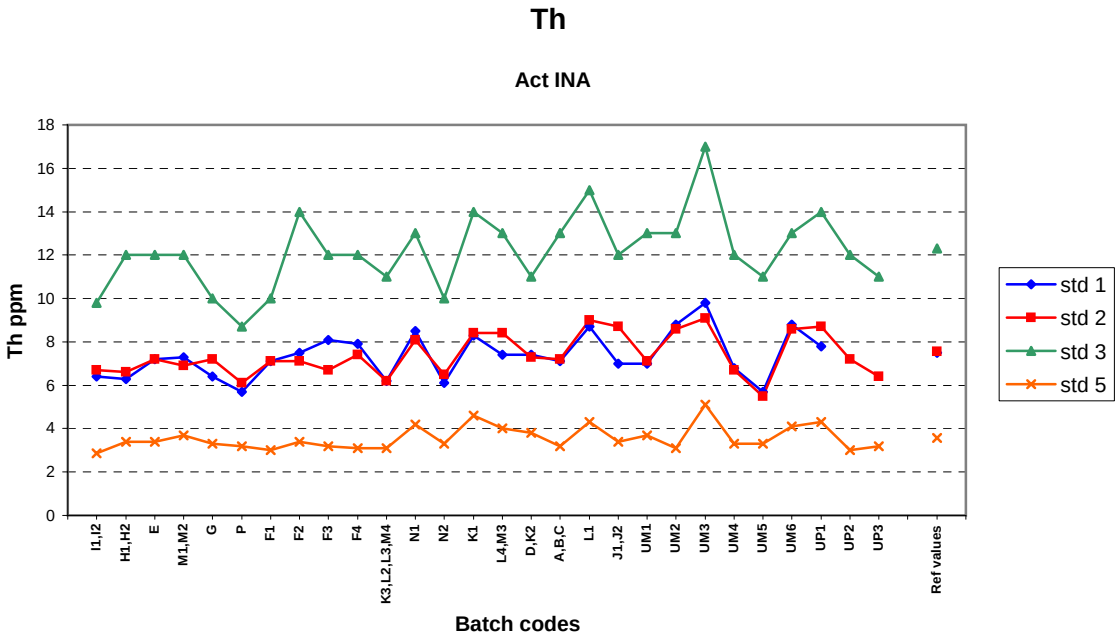


Figure 13j

Figure 13a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratory: Act *(Activation Laboratories Ltd.).*
Method: INA *(Instrumental Neutron Activation).*
Ref values: reference values (Table 6).

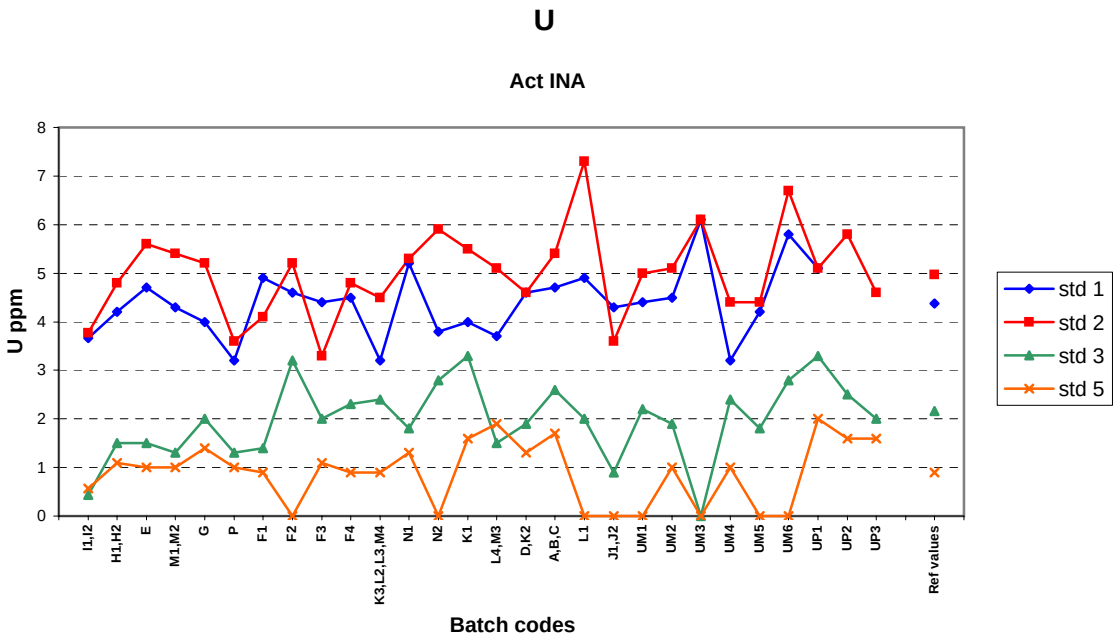


Figure 13k

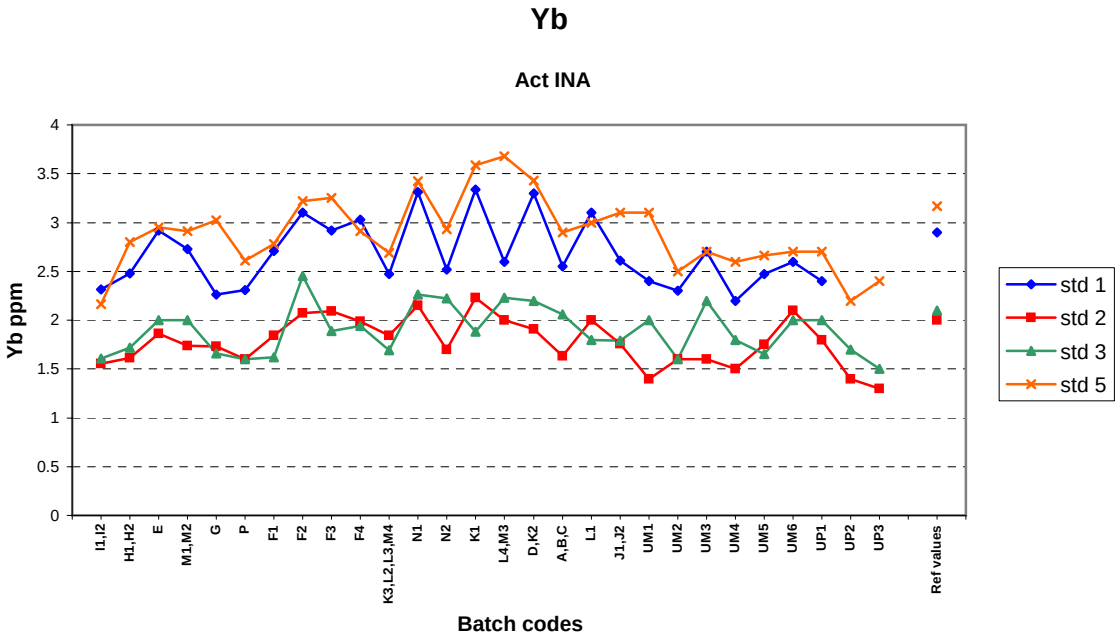


Figure 13l

Figure 13a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratory: Act *(Activation Laboratories Ltd.).*
Method: INA *(Instrumental Neutron Activation).*
Ref values: reference values (Table 6).

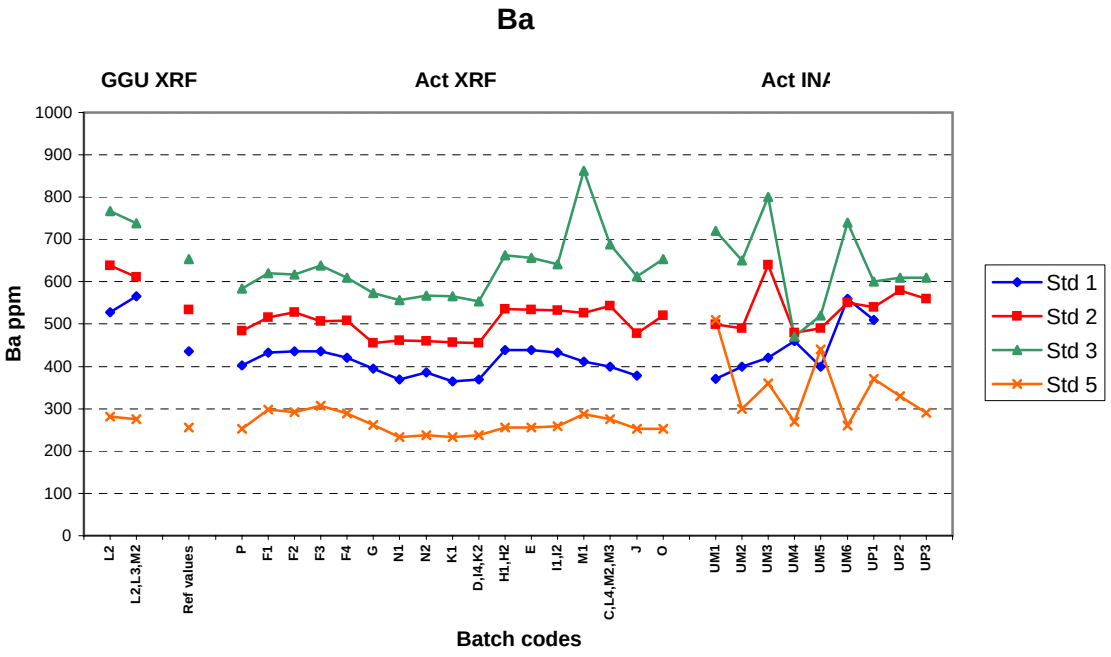


Figure 14a

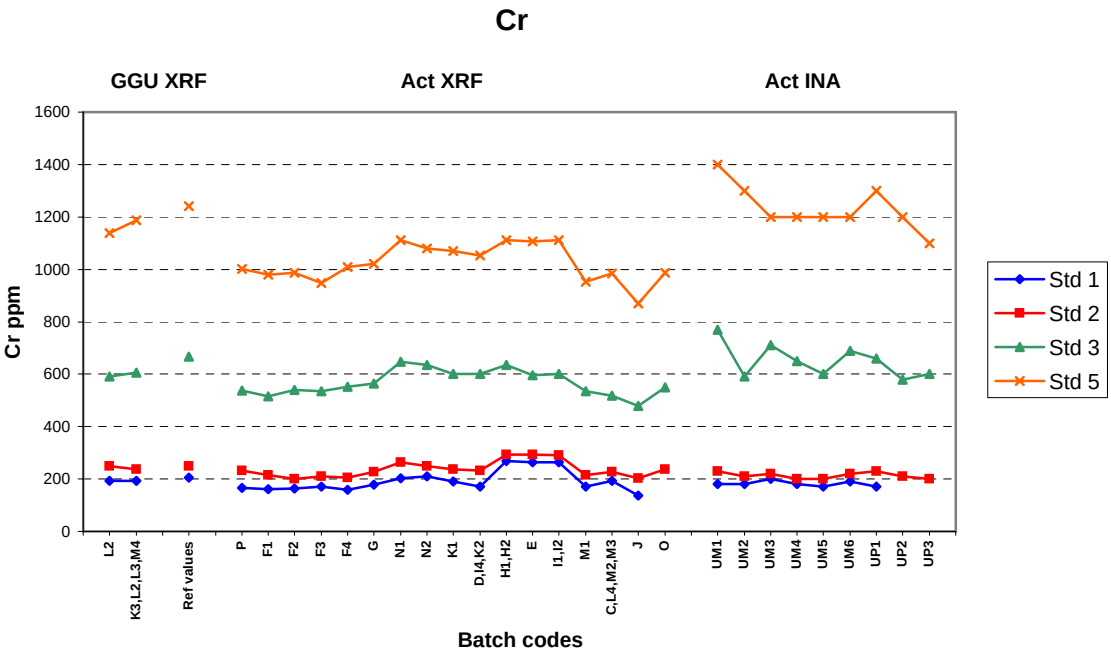


Figure 14b

Figure 14a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratories: Act *(Activation Laboratories Ltd.);* GGU *(Geological Survey of Greenland).*
Methods: XRF *(X-ray Fluorescence Spectrometry);*
ICP *(Inductively Coupled Plasma Emission Spectrometry).*
Ref values: reference values (Table 6).

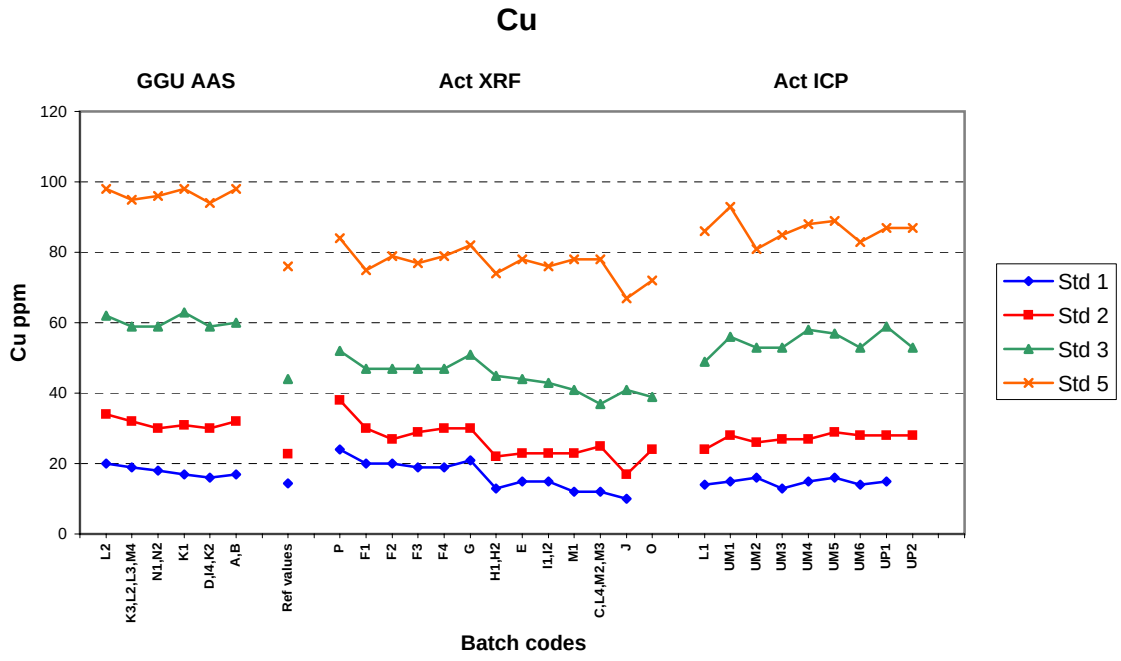


Figure 14c

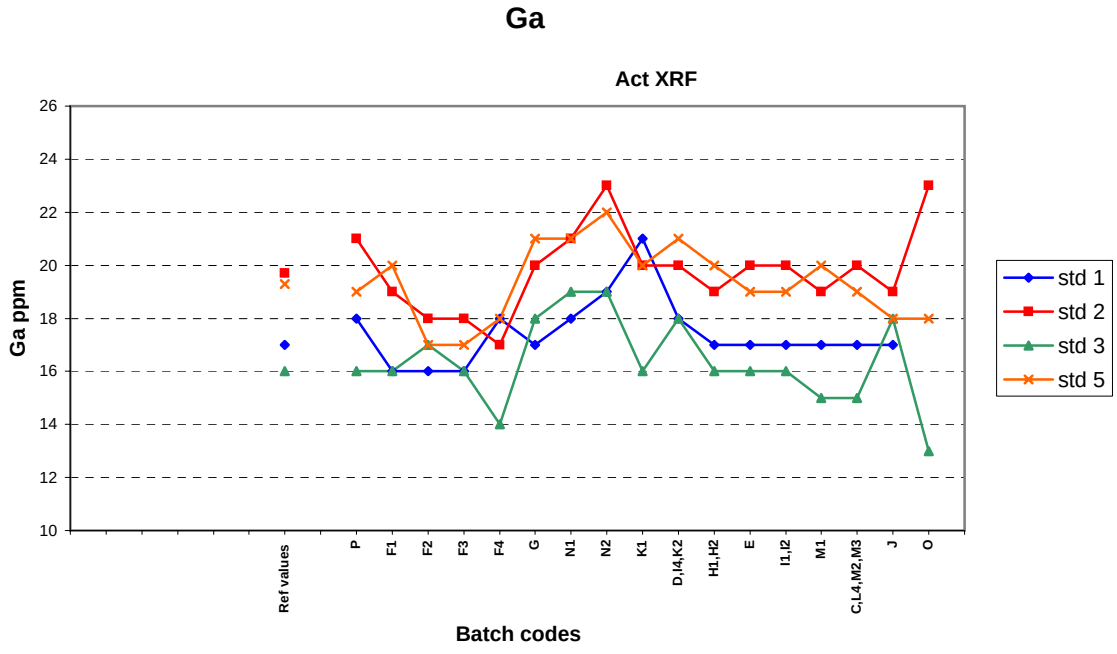


Figure 14d

Figure 14a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratories: Act *(Activation Laboratories Ltd.);* GGU *(Geological Survey of Greenland).*
Methods: XRF *(X-ray Fluorescence Spectrometry);* AAS *(Atomic Absorption Spectrometry),* ICP *(Inductively Coupled Plasma Emission Spectrometry).*
Ref values: reference values (Table 6).

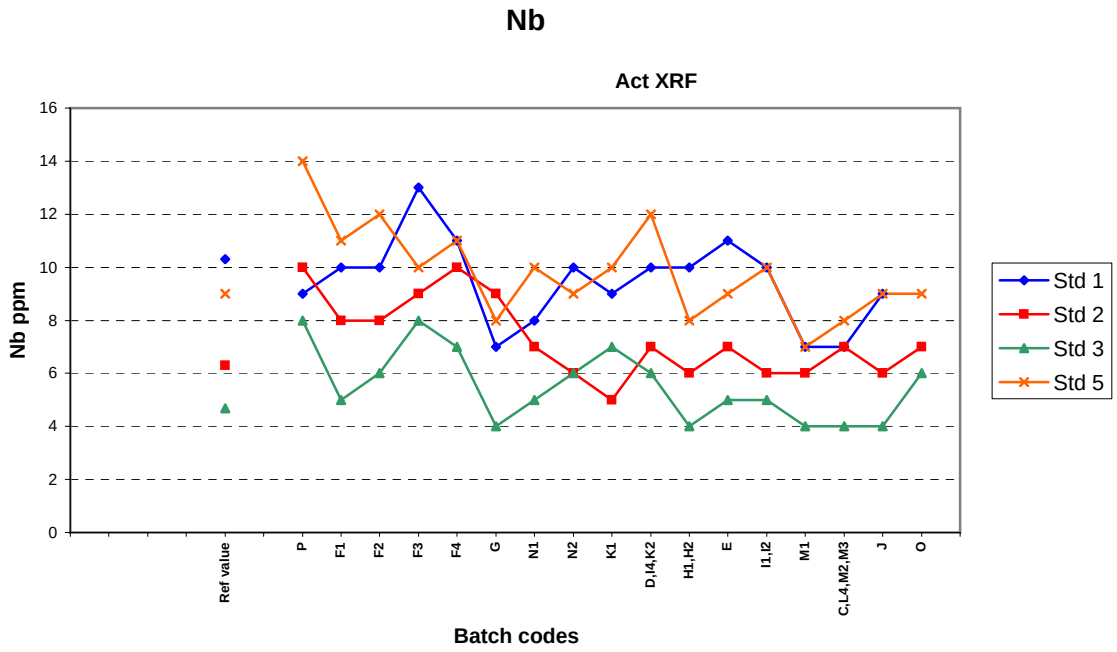


Figure 14e

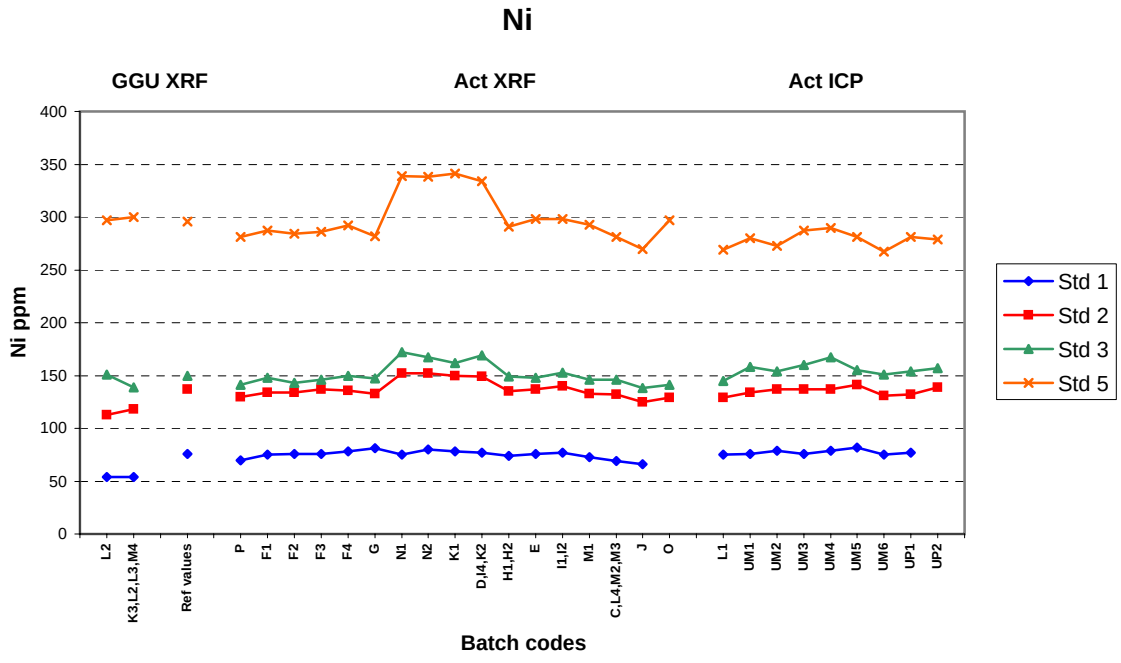


Figure 14f

Figure 14a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratories: Act *(Activation Laboratories Ltd.);* GGU *(Geological Survey of Greenland).*
Methods: XRF *(X-ray Fluorescence Spectrometry);*
ICP *(Inductively Coupled Plasma Emission Spectrometry).*
Ref values: reference values (Table 6).

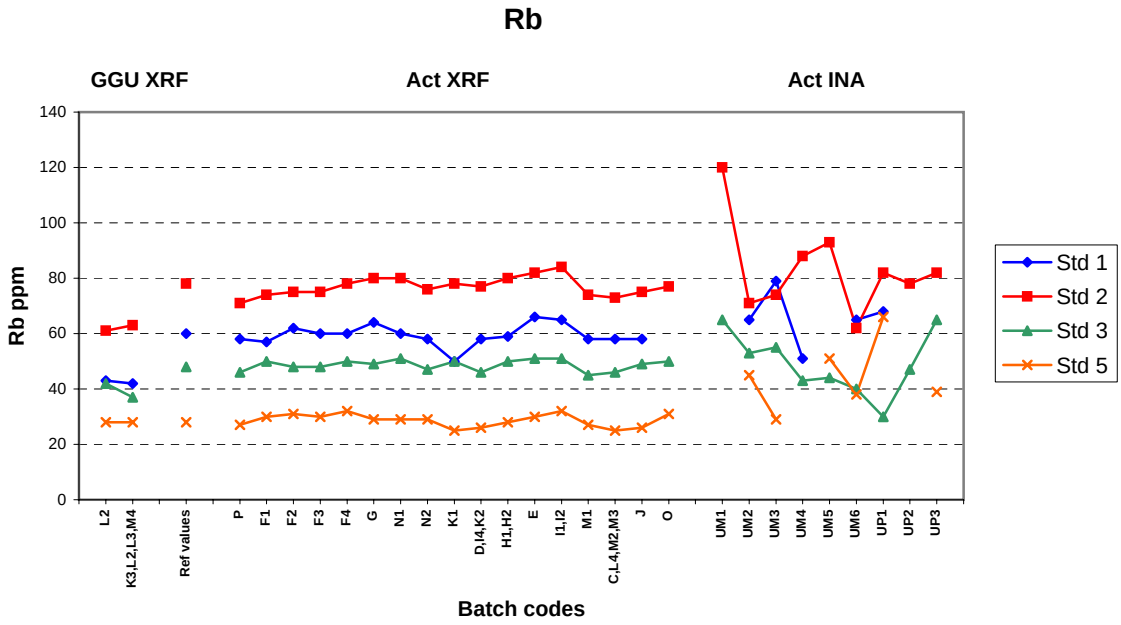


Figure 14g

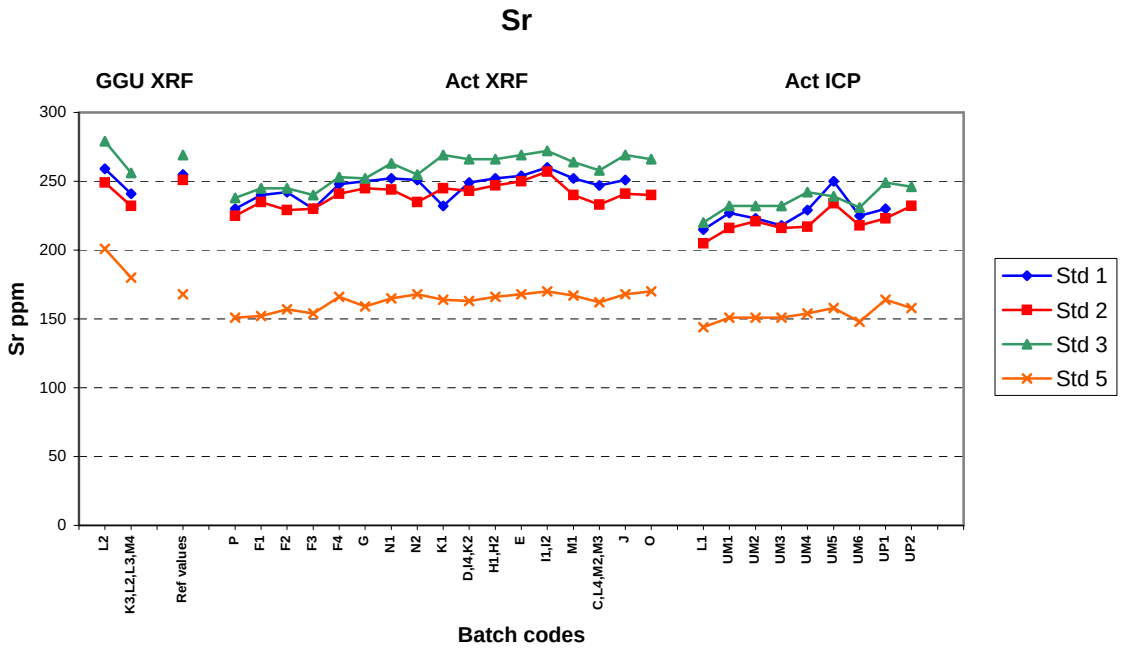


Figure 14h

Figure 14a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratories: Act *(Activation Laboratories Ltd.);* GGU *(Geological Survey of Greenland).*
Methods: XRF *(X-ray Fluorescence Spectrometry);*
ICP *(Inductively Coupled Plasma Emission Spectrometry).*
Ref values: reference values (Table 6).

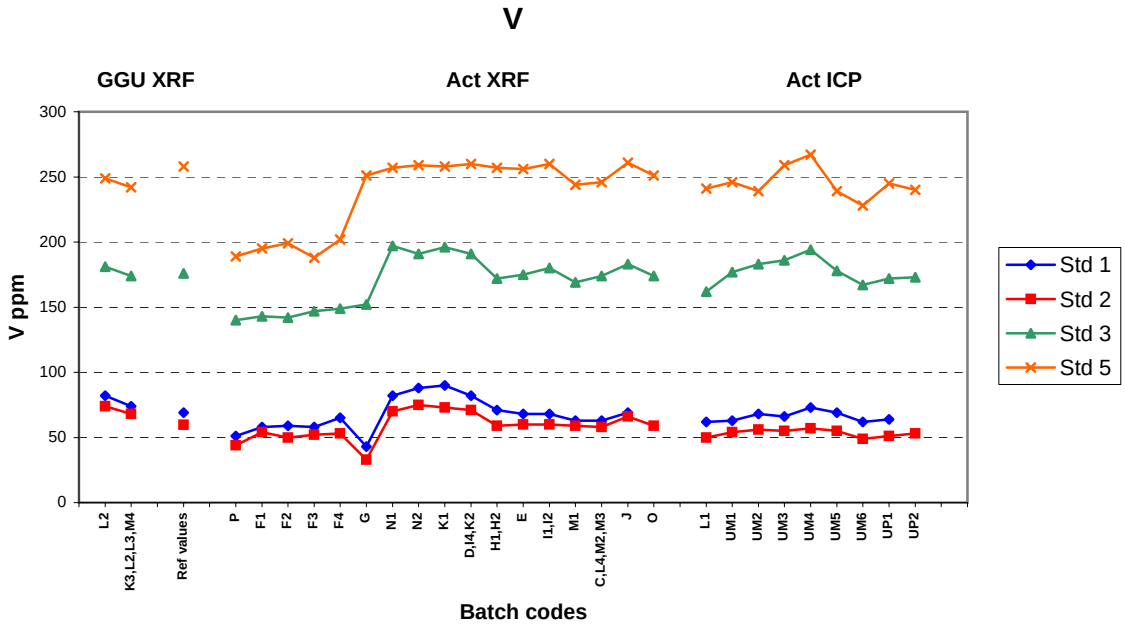


Figure 14i

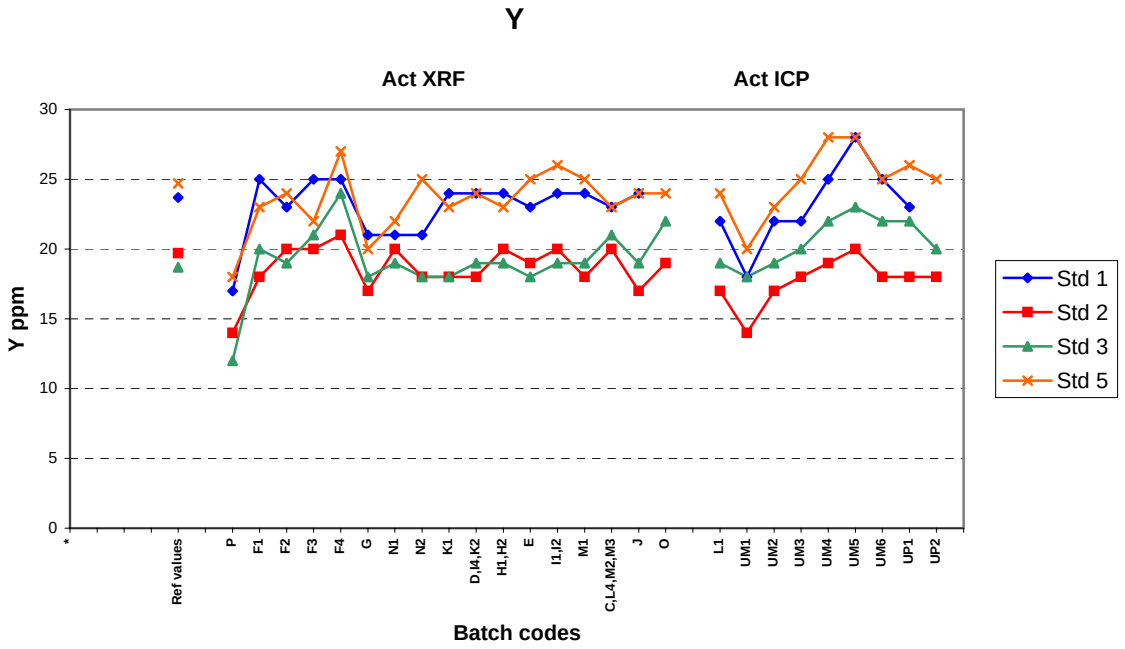


Figure 14j

Figure 14a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratories: Act *(Activation Laboratories Ltd.);* GGU *(Geological Survey of Greenland).*
Methods: XRF *(X-ray Fluorescence Spectrometry);*
ICP *(Inductively Coupled Plasma Emission Spectrometry).*
Ref values: reference values (Table 6).

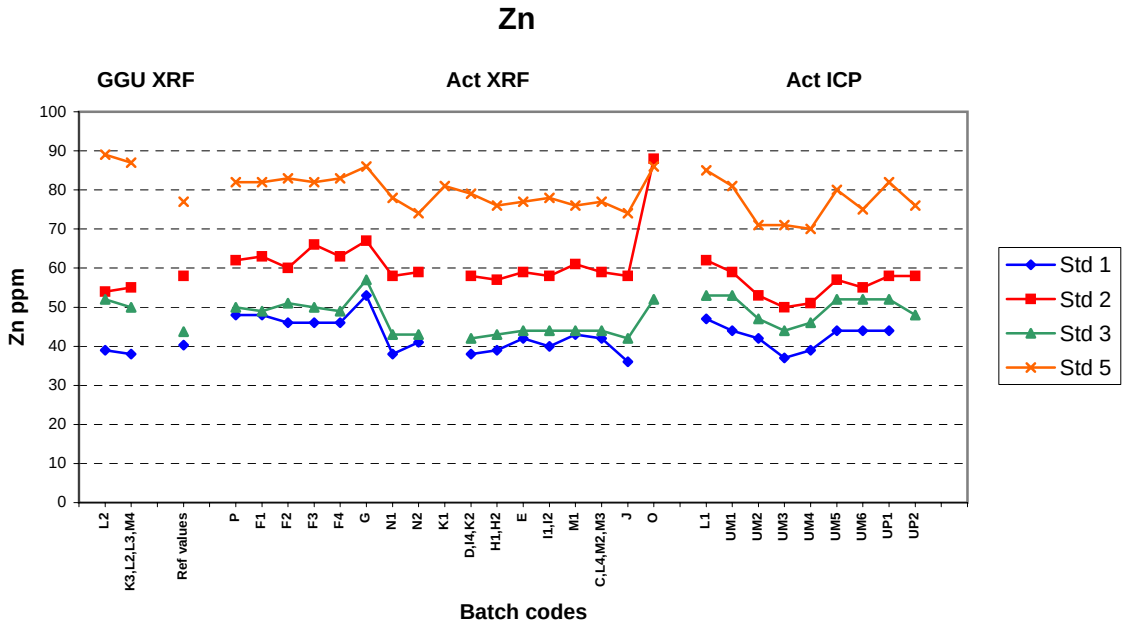


Figure 14k

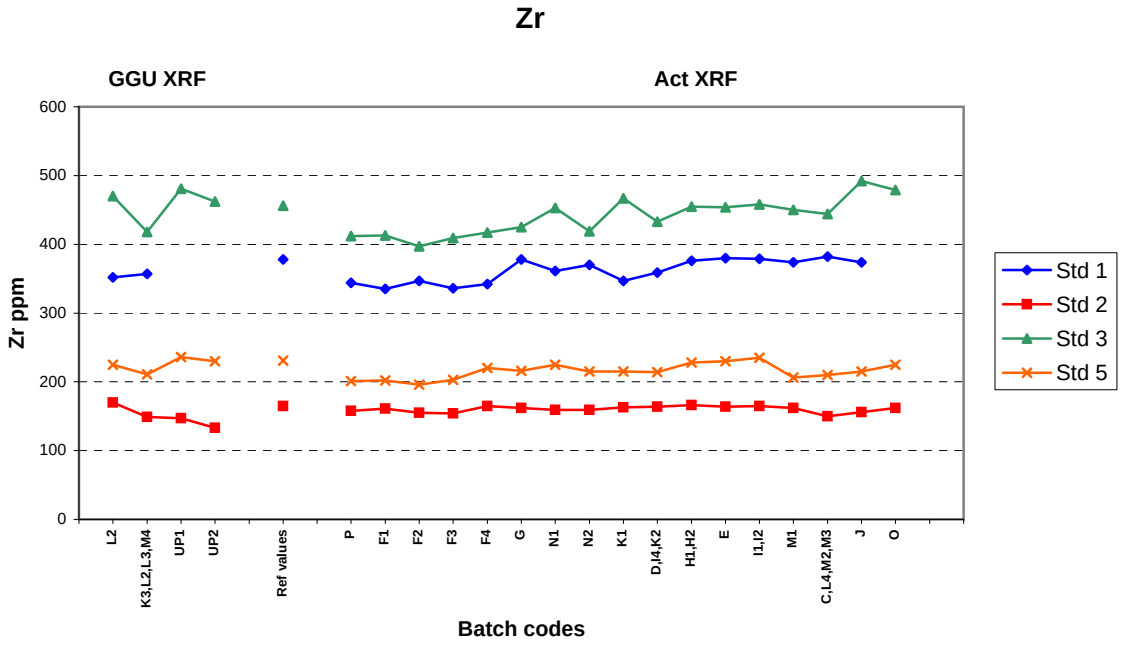
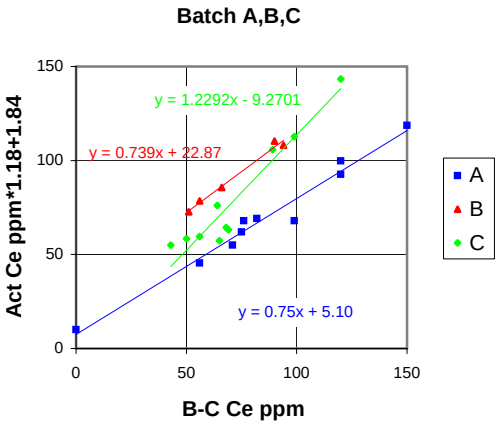
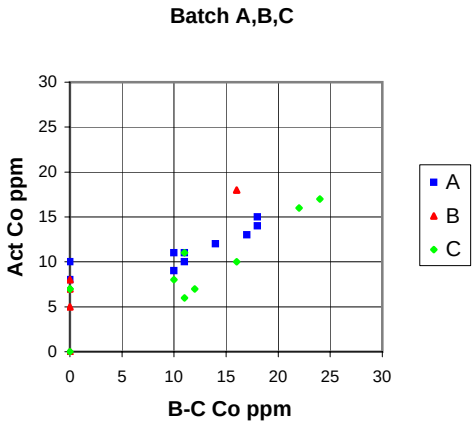


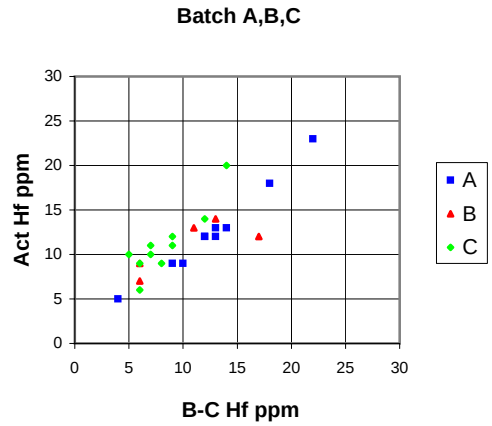
Figure 14l

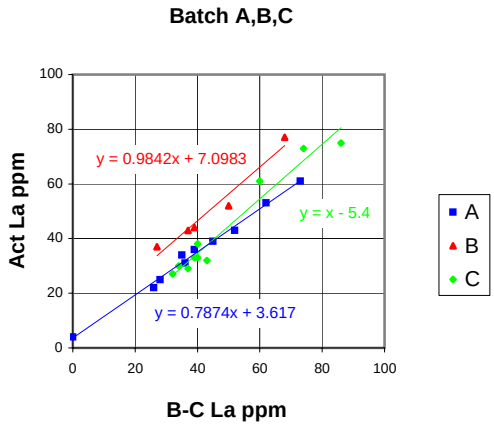
Figure 14a-l. *Variability of trace element data selected for the atlas as monitored by standards.*
Laboratories: Act *(Activation Laboratories Ltd.);* GGU *(Geological Survey of Greenland).*
Methods: XRF *(X-ray Fluorescence Spectrometry);*
ICP *(Inductively Coupled Plasma Emission Spectrometry).*
Ref values: reference values (Table 6).



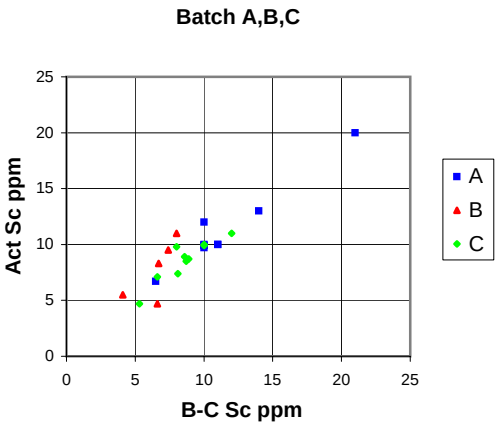


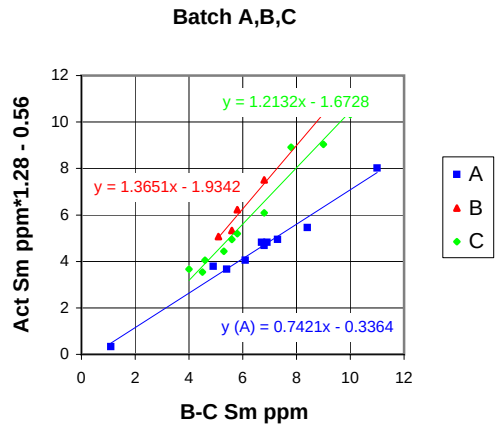
a **b** **Figure 16a, b**





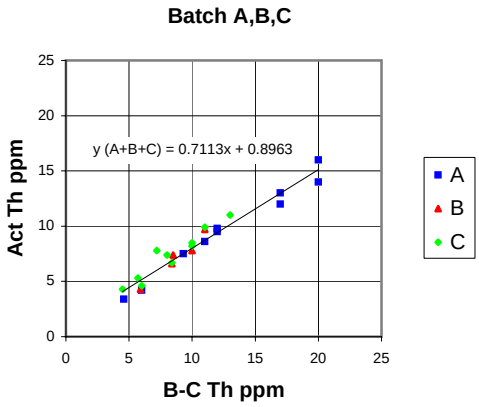
c **d** **Figure 16c, d**

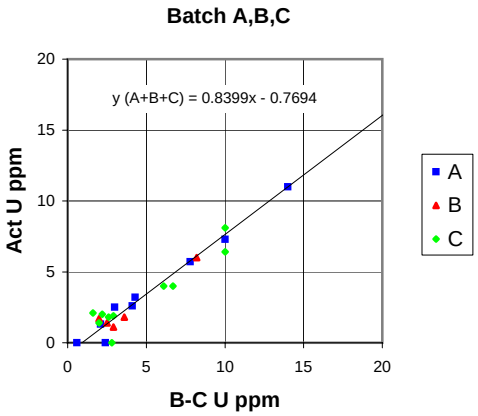




e **f** **Figure 16e, f**

Figure 16a-h. *Calibration of analytical values provided by B-C INA from batches A, B and C by means of calibrated Act INA data.*
Laboratories: B-C (Bondar-Clegg and Co. Ltd.); Act (Activation Laboratories Ltd.).
Method: INA *(Instrumental Neutron Activation).*





g **h** **Figure 16g, h**

Figure 16a-h. *Calibration of analytical values provided by B-C INA from batches A, B and C by means of calibrated Act INA data.*
Laboratories: B-C (Bondar-Clegg and Co. Ltd.); Act (Activation Laboratories Ltd.).
Method: INA *(Instrumental Neutron Activation).*

References

and additions to 'Bibliography on geochemical mapping of West and South Greenland'

Ady, B. & Tukiainen, T. (eds) 1995: Regional compilations of geoscience data from the Paamiut–Buksefjorden area, southern West and South-West Greenland. Thematic Map Series Grønlands Geologiske Undersøgelse **94/2**, 27 pp., 3 figs, 1 table, 63 maps with legends (in 2 volumes).

Schjøth, F., Garde, A.A., Jørgensen, M.S., Lind, M., Moberg, E., Nielsen, T.F.D., Rasmussen, T.M., Secher, K., Steenfelt, A., Stendal, H., Thorning, L. & Tukiainen, T. 2000: Mineral resource potential of South Greenland: the CD-ROM. Thematic map-data on CD-ROM. 1 CD-ROM.

Schjøth, F., Garde, A.A., Jørgensen, M.S., Lind, M., Moberg, E., Nielsen, T.F.D., Rasmussen, T.M., Secher, K., Steenfelt, A., Stendal, H., Thorning, L. & Tukiainen, T. 2000: Mineral resource potential of South Greenland: the CD-ROM. Danmarks og Grønlands Geologiske Undersøgelse Rapport **2000/57**, 36 pp.

Steenfelt, A. 1999a: Compilation of data sets for a geochemical atlas of West and South Greenland based on stream sediment surveys 1977 to 1997. Danmarks og Grønlands Geologiske Undersøgelse Rapport **1999/41**, 33 pp., 14 tabs, 52 figs.

Steenfelt, A. 1999b: Variability of XRF and AAS analyses from the Rock Geochemical Laboratory of the Geological Survey of Denmark and Greenland. Geology of Greenland Survey Bulletin **184**, 49–57.

Steenfelt, A. 2001 : Geochemical atlas of Greenland–West and South Greenland. Danmarks og Grønlands Geologiske Undersøgelse Rapport 2001/46, 39 pp. 1 CD-ROM or 54 printed maps.

Steenfelt, A., Dam, E. & Petersen, A. 1994: Reconnaissance geochemical mapping of the Paamiut region (61º25´to 62º45´N, 48º00´ to 50º00´W), South-West Greenland. Open File Series Grønlands Geologiske Undersøgelse **94/1**, 16 pp., 45 figs.

Steenfelt, A., Petersen, A. & Dam, E. 1994: Reconnaissance geochemical mapping of the Maniitsoq region (65º to 66ºN, 51º45´ to 53º30´W), southern West Greenland. Open File Series Grønlands Geologiske Undersøgelse **94/5**, 15 pp., 44 figs.

Steenfelt, A., Petersen, A. & Dam, E. 1994: Reconnaissance geochemical mapping of the Aasiaat region (68º to 68º45´N, 52º45´ to 54ºW), West Greenland. Open File Series Grønlands Geologiske Undersøgelse **94/6**, 10 pp., 38 figs.

Steenfelt, A., Dam, E. & Kyed. J. 1998: Geochemical mapping of the Uummannaq region (70º30´ to 72º30´N, 50º to 56ºW), central West Greenland. Danmarks og Grønlands Geologiske Undersøgelse Rapport **1998/40**, 25 pp.

Steenfelt, A., Thomassen, B., Lind, M. & Kyed, J. 1998: Karrat 97: reconnaissance mineral exploration in central West Greenland. Geology of Greenland Survey Bulletin **180**, 73–80.

Steenfelt, A., Dam, E. & Kyed. J. 1999: Geochemical mapping of the Upernavik – Kap Seddon region North-West Greenland. Danmarks og Grønlands Geologiske Undersøgelse Rapport **1999/43**, 21 pp., 45 maps.

Steenfelt, A., Nielsen, T.F.D. & Stendal, H. 2000: Mineral resource potential of South Greenland: review of new digital data sets. Danmarks og Grønlands Geologiske Undersøgelse Rapport **2000/50**, 47 pp.

Thomassen, B. 1990: Prospecting for base and noble metals in the Íngia area, West Greenland: analytical results. Open File Series Grønlands Geologiske Undersøgelse **90/2**, 61 pp.

Thomassen, B. 1991: Gold and base metal potential of the Íngia area, central West Greenland. Open File Series Grønlands Geologiske Undersøgelse **91/5**, 115 pp.

Thomassen, B. 1992: The gold and base metal potential of the Lower Proterozoic Karrat Group, West Greenland. Rapport Grønlands Geologiske Undersøgelse **155**, 57–66.

Thomassen, B. 1993: Update on the gold and base metal potential of the Íngia area, central West Greenland. Open File Series Grønlands Geologiske Undersøgelse **93/7**, 66 pp.

Thomassen, B., Kyed, J., Tukiainen, T. & Steenfelt, A. 1999: Upernavik 98: reconnaissance mineral exploration in North-West Greenland. Geology of Greenland Survey Bulletin **183**, 39–45.