

Certification Report

Certified Reference Material

BAM-M322

AlMn1Cu

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Summary

This report describes preparation, analysis and certification of the aluminium alloy reference material BAM-M322. The certified reference material (CRM) is available in the form of discs (65 mm diameter and 30 mm height). It is intended for establishing and checking the calibration of optical emission and X-ray spectrometers (excluding micro-analysis) for the analysis of samples of similar matrix composition. It is also suitable for validation and quality control of wet chemical analysis methods. The following mass fractions and uncertainties have been certified:

Element	Mass fraction¹⁾ in %	Uncertainty²⁾ in %
Si	0.696	0.021
Fe	0.475	0.014
Cu	0.200	0.006
Mn	1.310	0.018
Mg	0.226	0.005
Cr	0.1185	0.0024
Ni	0.0293	0.0005
Zn	0.1053	0.0020
Ti	0.0279	0.0009
	in mg/kg	in mg/kg
Be	7.2	0.2
Bi	76.5	2.8
Ca	19.9	1.7
Cd	10.1	0.3
Co	9.7	0.4
Ga	57.7	3.0
Li ³⁾	18.1 ³⁾	0.8
Na ⁴⁾	15.7 ⁴⁾	1.1
Pb	92.0	2.5
Sn	97.7	2.4
V	114.1	2.5
Zr	98.0	1.9

¹⁾ Unweighted mean value of the means of accepted sets of data (consisting of at least 5 single results), each set being obtained by a different laboratory and/or a different method of measurement.
²⁾ Estimated expanded uncertainty U with a coverage factor of $k = 2$, corresponding to a level of confidence of approx. 95 %, as defined in the Guide to the Expression of Uncertainty in Measurement, (GUM, ISO/IEC Guide 98-3:2008).
³⁾ Depending on the individual sample number: $\mathbf{M(Li)} = (\mathbf{N-48}) \times 0.030903 + 18.1$
⁴⁾ Depending on the individual sample number: $\mathbf{M(Na)} = (\mathbf{N-48}) \times 0.040625 + 15.7$

This report contains detailed information on the preparation of the CRM as well as on homogeneity investigations and on the analytical methods used for certification analysis.
The certified values are based on the results of ten laboratories which participated in the certification inter-laboratory comparison.

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List of abbreviations

(if not explained elsewhere)

CRM	certified reference material
FAAS	flame atomic absorption spectrometry
ETAAS	Electrothermal atomic absorption spectrometry
ICP-OES	inductively coupled plasma optical emission spectrometry
ICP-MS	inductively coupled plasma mass spectrometry
SOES	spark optical emission spectrometry
XRF	X-ray fluorescence spectrometry
<i>M</i>	mean value
<i>n</i>	number of accepted data sets
<i>s</i>	standard deviation of an individual data set
<i>S_M</i>	standard deviation of laboratory means
<i>S_{rel}</i>	relative standard deviation
\bar{s}_i	square root of mean of variances of data sets under repeatability conditions
<i>M_i</i>	single result
I	ICP-OES (Tables 2 – 23)
I(R)	ICP-OES, revised value (Tables 2 – 23)
IMS	ICP-MS (Tables 2 – 23)
A	FAAS (Tables 2 – 23)
EA	ETAAS (Tables 2 – 23)
FES	flame emission spectrometry (Tables 2 – 23)
P	spectrophotometry (Tables 2 – 23)
-s	dissolution in acid (Tables 2 – 23)
-a	dissolution in base (Tables 2 – 23)

1. Introduction

In the metal-producing and metal-working industry mainly spark emission spectrometry (SOES) and X-ray fluorescence spectrometry (XRF) are used for reception inspection of raw materials, e.g. scrap, for quality control of end products and production control. These time-saving analytical techniques require suitable reference materials for calibration and recalibration. The certified reference material BAM-M322 is based on the aluminium alloy AIMn1Cu, which has a lot of technical applications.

The CRM was produced in close cooperation with the working group „Aluminium“ of the Committee of Chemists of the Society of Metallurgists und Miners (GDMB). Since all the laboratories participating in this certification project are highly experienced with aluminium analysis and had already participated in earlier inter-laboratory comparisons, there was no preceding round robin for qualification necessary.

Certification was carried out on the basis of ISO 17034 [1] and the relevant ISO-Guides [2, 3].

2. Companies/laboratories involved

Manufacturing of the material:

- Constellium, Centre de Recherches de Voreppe, Voreppe, France

Test for homogeneity:

- Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany
- Constellium, Centre de Recherches de Voreppe, Voreppe, France

Participants in the certification inter-laboratory comparison:

ALERIS Rolled Products Germany GmbH, Koblenz, Germany

AMAG Austria Metall AG, Ranshofen, Austria

Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany

Hydro Aluminium Rolled Products GmbH, R&D, Bonn, Germany

Hydro Aluminium Rolled Products GmbH, Hamburg, Germany

Łukasiewicz Research Network – Institute of Non-Ferrous Metals, Gliwice, Poland

Leichtmetall Aluminium Giesserei Hannover GmbH, Hannover, Germany

Otto Fuchs KG, Meinerzhagen, Germany

revierlabor, Essen, Germany

TRIMET Aluminium SE, Essen, Germany

Statistical evaluation of the data:

- Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany

3. Candidate material

The candidate material was produced by Constellium, Centre de Recherches de Voreppe, Voreppe, France. About 500 kg of an aluminium melt were doped with the desired elements. The melt was cast into six rods (A - F) with a length of 4450 mm each. 250 mm on both ends of each rod were discarded. The rods were cut into segments of 800 mm length (A1, A2, A3, A4, B1, B2, ..., F3, F4). Between the segments 15-mm discs (AA, AB, AC, AD, AE, BA, BB, ..., FD, FE) were taken for homogeneity testing (see Fig. 1).

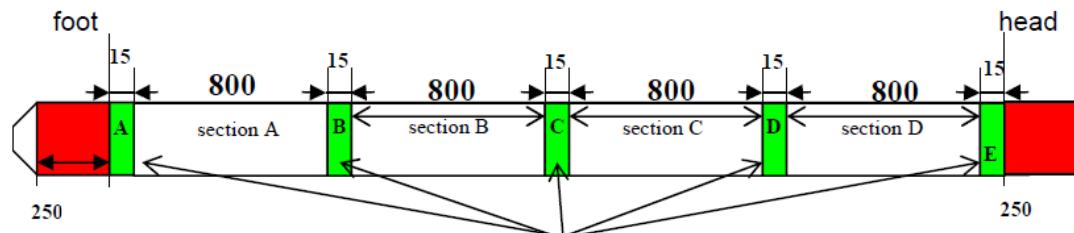


Fig. 1: Preparation of the rods cast (all figures in mm)

In total, 576 discs with a diameter of ca. 65 mm and 30 mm height were obtained.

4. Homogeneity testing

Possible reasons for an inhomogeneous distribution of elements in the raw material may be a change of the composition of the melt during the casting procedure because some elements may volatize or because of possible segregation during the solidification of the material. Since the raw material was produced by casting of a rod, concentration gradients can occur over the length of the rod (axial) as well as over the area of the rod (radial, see Fig. 2):

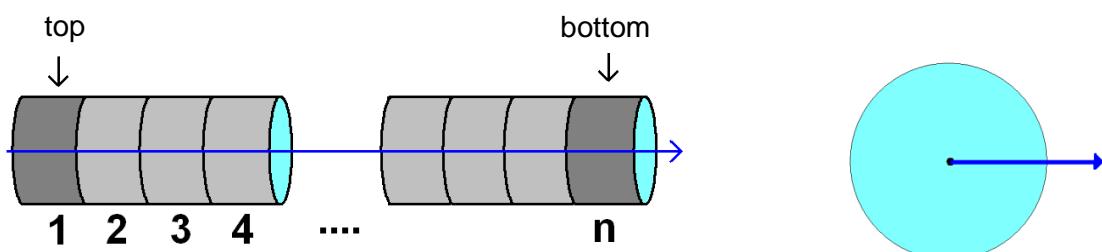


Fig. 2: Axial and radial composition gradient

Therefore, it is necessary to investigate the raw material for both axial and radial inhomogeneities. Radial homogeneity testing of the candidate material using spark emission spectrometry was performed at Constellium, Centre de Recherches de Voreppe on the discs taken from the rods as shown in Fig. 1. In total 30 discs were investigated, this corresponding to ca. 5.5 % of the whole batch. The estimate of analyte-specific inhomogeneity contribution u_{bb} to be included into the total uncertainty budget was calculated according to ISO Guide 35 [3] using Eq. (1) and Eq. (2):

$$s_{bb} = \sqrt{\frac{MS_{among} - MS_{within}}{n}} \quad (1)$$

$$u_{bb}^* = \sqrt{\frac{MS_{within}}{n}} \sqrt[4]{\frac{2}{N(n-1)}} \quad (2)$$

where:

MS_{among} mean of squared deviations between discs (from 1-way ANOVA, see Annex 1)

MS_{within} mean of squared deviations within one disc (from 1-way ANOVA)

n number of replicate measurements per disc

N number of discs selected for homogeneity study

s_{bb} signifies the between-discs standard deviation whereas u_{bb}^* denotes the maximum heterogeneity that can potentially be hidden by an insufficient repeatability of the applied measurement method (which has to be considered as the minimum uncertainty contribution). In any case the larger of the two values was used as $u_{bb}(1)$. Eq. (1) does not apply if MS_{within} is larger than MS_{among} .

For the elements Li and Na a decrease of the mass fraction over the length of the rods was observed. This is a result of the low boiling points of the two elements which result in losses from the melt during the melting process. The homogeneity test shows a more or less linear decrease of the two elements over the length of the rods. Therefore, the mass fractions of the two elements in the certificate are given as functions of the sample number which determines the position in the rod.

These functions are calculated based on the spark emission results from homogeneity test and wet chemical results from one laboratory which determined Li and Na on samples taken over the length of the rods (see Tables 18 and 19, Lab. 9/EA):

$$M_x = (N_x - 48) \cdot \frac{\Delta}{n} \cdot M \quad (3)$$

with

M_x : Mass fraction of Disc x

M : Mass fraction obtained from certification interlaboratory comparison

N_x : individual number of disc representing its position in the rod ($1 < N_x < 96$)

n : number of discs per rod ($n = 96$)

Δ : Mean difference of mass fractions over the length of the rods (calculated from the data of SOES and Lab. 9/EA)

Δ (Li) = 2,966666

Δ (Na) = 3,9

In addition to the tests performed over the length of the rods three discs were tested for homogeneity over the area (possible segregation from the outer part to the centre). To perform this test SOES analysis was carried out in circles (outer circle: 20 sparks, mean circle: 14 sparks, inner circle: 8 sparks; centre: 1 spark). For some elements data from the accompanying spark emission round robin test was used because there the BAM-spectrometer was not sensitive enough (Ti, B, Be, Bi, Cd, Co, Pb, and Sn). Calculation was done in the same way as for the other elements while the number of sparks were different (outer circle: 4 sparks, inner circle: 4 sparks; centre: 1 spark).

The analyte-specific within-disc uncertainty component $u_{bb}(2)$ was calculated in the same way as for the total batch. To calculate the necessary data an unbalanced ANOVA was carried out taking into

account that the number of single measurements is different for the centre, the inner and the outer circle. For technical reasons, at r_0 (centre) only one measurement is possible. An ANOVA requires a minimum of two measurements per factor value. Thus, the value for r_0 should be replaced by a dummy. This dummy is defined as follows:

The two values replacing the one measured have a mean equal to the value measured, and a standard deviation equal to the average within-variation. This resembles the situation where one could take two independent measurements at the same place, with values deviating by the average standard deviation (non-destructive testing method). A first guess for the average standard deviation may be calculated from the data for r_{in} (inner circle), r_{mean} (mean circle) and r_{out} (outer circle). An inhomogeneity component for the radius of the disc results from these calculations. From all these values a combined inhomogeneity component is calculated. This component is compared with the within standard deviation calculated from the ANOVA-data. The higher component is used for uncertainty calculation.

Annex 1 and 2 show the results of the homogeneity calculations.

5. Characterisation study

5.1 Analytical methods

Ten laboratories participated in the certification inter-laboratory comparison. All laboratories were highly experienced in the analysis of aluminium and aluminium alloys and participated successfully in former certification inter-laboratory comparisons. For some elements part of the laboratories used more than one analytical method reporting more than one data set.

The laboratories were asked to analyse six subsamples. They were free to choose any suitable analytical method. Table 1 shows the analytical methods used by the participating laboratories. For all analytical methods where a calibration was necessary this calibration was performed using liquid standard solutions. All participating laboratories were asked to use only standard solutions prepared from pure metals or stoichiometric compounds or well checked commercial calibration solutions.

Table 1: Analytical procedures used by the participating laboratories

Lab-No.	Element	Sample mass	Sample pretreatment	Analytical method
2*	Si, Fe, Cu, Mn, Mg, Zn	0.5 g	Dissolution with NaOH	ICP-OES, calibration with pure metals or pure chemicals, matrix matching with pure Al (5N5)
	V	0.5 g	Dissolution with NaOH	ICP-OES, commercial mono-element solution (Merck certipur), matrix matching with pure Al (5N5)
	Cr, Ca, Na	0.5 g	Dissolution with HNO_3/HF	ICP-OES, calibration with pure metals or chemicals, matrix matching with pure Al (5N5)
	Ti	0.5 g	Dissolution with HNO_3/HF	ICP-OES, commercial mono-element solution (Merck certipur), matrix matching with pure Al (5N5)
	Ni, B, Bi, Co, Li, Pb, Sn, Zr	0.5 g	Dissolution with HNO_3/HF	ICP-MS, calibration with pure metals or pure chemicals, matrix matching with pure Al (5N5)
	Be, Cd, Ga, Hg	0.5 g	Dissolution with HNO_3/HF	ICP-MS, commercial mono-element solution (Merck certipur), matrix matching with pure Al (5N5)

*accredited acc. to ISO IEC 17025

Table 1 (cont.): Analytical procedures used by the participating laboratories

Lab-No.	Element	Sample mass	Sample pretreatment	Analytical method
3*	Si, Fe, Cu, Mn, Mg, Cr, Ni, Zn, Ti, Be, Bi, Cd, Co, Hg, Pb, Sn, V, Zr	0.1 g	Dissolution with NaOH/H ₂ O ₂	ICP-OES, commercial mono-element solution
	B, Ca, Ga, Li, Na	0.5 g	Dissolution with HNO ₃ /HF	ICP-OES, commercial mono-element solution
4	Si	0.5 g	Dissolution with NaOH	Spectrophotometry, commercial mono-element solution, matrix matching with pure Al (Merck, Ultrascientific)
	Fe, Cu, Mn, Mg, Cr, Zn	0.2 g	Dissolution with HNO ₃ /HCl	ICP-OES, commercial mono-element solutions, matrix matching with pure Al (Merck, Ultrascientific)
	Ni, Ti, B, Be, Bi, Ca, Cd, Co, Ga, Li, Na, Pb, Sn, V, Zr	1 g	Dissolution with HNO ₃ /HCl	ICP-OES, commercial mono-element solutions, matrix matching with pure Al (Merck, Ultrascientific)
5*	Si, Cu, Mn, Mg, Cr, Ni, Zn, Bi, Cd, Co, Ga, Li, Pb	0.5 g	Dissolution with NaOH	ICP-OES, commercial mono-element solutions (Merck)
5*	Fe, Ti, Be, Sn, V, Zr	0.5 g	Dissolution with NaOH	ICP-OES, commercial mono-element solutions (Labkings)
6	Si, Be, Ga, Hg	0.5 g	Dissolution with NaOH	ICP-OES, calibration with pure metals or pure chemicals, matrix matching with pure Al
	Fe, Cu, Mn, Mg, Cr, Ni, Zn, B, Bi, Ca, Cd, Co, Li, Na, Pb, Sn, V, Zr	0.5 g	Dissolution with HCl/H ₂ O ₂	ICP-OES, calibration with pure metals or pure chemicals, matrix matching with pure Al
7*	Si, Fe, Cu, Mn, Mg, Cr, Ni, Zn, Ti, B, Be, Bi, Ca, Cd, Co, Ga, Li, Na, Pb, Sn, V, Zr,	0.5 g	Dissolution with HNO ₃ /HCl/HF	ICP-OES, calibration with matrix matched standards, commercial multi-element standard solutions (Merck, Perkin Elmer)
	Cr, Ni, Zn, Sn, V, Zr, Be, Bi, Cd, Co, Ga, Li, Na, Pb, Sn, V, Zr	0.5 g	Dissolution with HNO ₃ /HF	ICP-MS, with matrix matched standards, commercial mono-element standard solutions (Merck, Perkin Elmer)
8	Si, Fe, Cu, Mn, Mg, Cr, Ni, Zn, Ti	0.3 g	Dissolution with NaOH/HNO ₃	ICP-OES with matrix matched standards, commercial mono-element solutions (Merck)
	Fe, Cu, Mn, Mg, Cr, Ni, Zn, Ti, B, Bi, Cd, Co	0.3 g	Dissolution with HCl/H ₂ O ₂	ICP-OES with matrix matched standards, commercial mono-element solutions (Merck)
9*	Si, Mn, Zr, V	0.25 g	Dissolution with NaOH	Spectrophotometry, calibration with commercial mono-element solutions (Merck)
	Fe, Ti	0.5 g	Dissolution with HCl/H ₂ O ₂	Spectrophotometry, calibration with commercial mono-element solutions (Merck)
	Na	0.25 g	Dissolution with HCl/HNO ₃ /HF	ETAAS, calibration with commercial mono-element solution (Merck)

*accredited acc. to ISO IEC 17025

Table 1 (cont.): Analytical procedures used by the participating laboratories

	Li	0.25 g	Dissolution with HCl/HNO ₃ /HF	Atomic emission spectrometry, calibration with commercial mono-element solution (Merck)
	Fe, Cr, Mg, Mn, Zn	1 g	Dissolution with HCl/H ₂ O ₂	FAAS, calibration with commercial mono-element solution (Merck)
	Fe, Cu, Mn, Mg, Cr, Ni, Zn, Ti, B, Be, Bi, Cd, Co, Ga, Li, Na, Pb, Sn, V, Zr	1 g	Dissolution with HCl/HNO ₃ , Addition of HF and mannite	ICP-OES, calibration with matrix matched standards, commercial mono-element solutions
	Si, Fe, Cu, Mn, Mg, Cr, Ni, Zn, Ti, Be, Bi, Cd, Sn, Zr	0.25 g	Dissolution with NaOH	ICP-OES, calibration with matrix matched standards, commercial mono-element solution
10	Si, Fe, Cu, Mn, Mg, Cr, Ni, Zn, Ti, Be, Bi, Cd, Co, Ga, Sn, V, Zr	0.25 g	Dissolution with NaOH/HNO ₃	ICP-OES, calibration with commercial mono-element solutions (Bernd Kraft)
12	Si, Fe, Cu, Mn, Mg, Cr, Ni, Zn, Ti, B, Be, Bi, Ca, Cd, Co, Ga, Hg, Li, Pb, Sn, V, Zr	0.5 g	Dissolution with NaOH/HNO ₃	ICP-OES, calibration with matrix matched standards, commercial mono-element solutions (Merck certipur)

*accredited acc. to ISO IEC 17025

5.2 Analytical results and statistical evaluation

The analytical results of the inter-laboratory certification comparison are listed in Tables 2 to 23. These tables show the single results (M_i) of each laboratory, the respective laboratories' mean values (M), absolute and relative intra-laboratory standard deviation (s and s_{rel} , respectively), the standard deviation of laboratory means (s_M), and in addition the square root of mean of variances of data sets under repeatability conditions (\bar{s}_i) where n is the number of accepted data sets. The continuous line marks the certified value (mean of the laboratories' means), the broken lines mark the standard deviation, calculated from the laboratories' means.

In the related figures for each laboratory its mean value and single standard deviation is given. Outliers which have been excluded are highlighted in yellow.

Table 2: Results for Si

Lab./Meth.	8/I-a	7/I-s_2(R)	12/I-a	9/I-a	5/I-a_1	6/I-a	10/I-a	9/P	5/I-a_2	2/I-a	4/P	3/I-a		
M_i [%]	0.6623	0.682	0.696	0.688	0.693	0.689	0.698	0.694	0.709	0.7126	0.709	0.752		n
	0.6706	0.682	0.688	0.687	0.691	0.694	0.694	0.690	0.704	0.7097	0.706	0.724		12
	0.6666	0.681	0.703	0.694	0.689	0.696	0.691	0.710	0.705	0.7122	0.712	0.724		
	0.6608	0.682	0.685	0.686	0.686	0.698	0.691	0.698	0.706	0.7020	0.712	0.734		
	0.6570	0.683	0.676	0.700	0.686	0.697	0.697	0.692	0.709	0.7026	0.712	0.712		
	0.6564	0.682	0.683	0.683	0.692	0.690	0.698	0.700	0.705	0.7021	0.713	0.718		
M [%]	0.662	0.682	0.689	0.689	0.689	0.694	0.695	0.698	0.706	0.707	0.711	0.727		0.696
s [%]	0.0055	0.0007	0.0096	0.0063	0.0029	0.0037	0.0033	0.0073	0.0020	0.0052	0.0027	0.0143	s_M [%]	0.0163
s_{rel}	0.0083	0.0010	0.0140	0.0091	0.0043	0.0053	0.0048	0.0104	0.0029	0.0073	0.0037	0.0196	\bar{s}_i [%]	0.0064
														0.0234

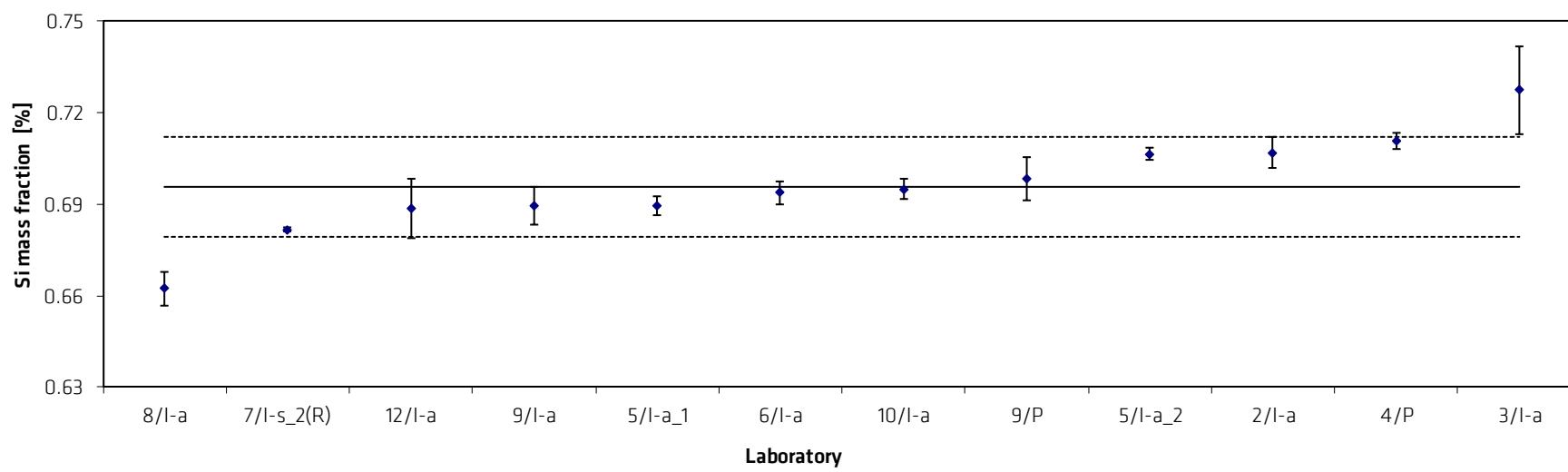


Table 3: Results for Fe

Lab./Meth.	5/I-a_1	9/I-a	5/I-a_2	8/I-a	9/A-s	4/I-s	3/I-a	2/I-a	12/I-a	9/P	8/I-s	7/I-s_1	6/I-s	9/I-s	10/I-a	7/I-s_2		
M_i [%]	0.457	0.451	0.456	0.4659	0.468	0.488	0.4745	0.4762	0.478	0.4734	0.4776	0.459	0.4879	0.4908	0.499	0.508	n	
	0.454	0.451	0.453	0.4695	0.468	0.469	0.4602	0.4735	0.479	0.4784	0.4839	0.536	0.4822	0.4844	0.501	0.506	16	
	0.450	0.461	0.455	0.4675	0.469	0.471	0.4624	0.4748	0.477	0.4766	0.4826	0.520	0.4812	0.4867	0.496	0.498		
	0.451	0.457	0.454	0.4688	0.471	0.466	0.4861	0.4713	0.476	0.4806	0.4827	0.451	0.4874	0.4810	0.496	0.504		
	0.449	0.460	0.458	0.4647	0.469	0.455	0.4670	0.4724	0.467	0.4798	0.4796	0.473	0.4806	0.4865	0.496	0.499		
	0.455	0.450	0.454	0.4657	0.473	0.469	0.4714	0.4723	0.474	0.4809	0.4804	0.451	0.4811	0.4890	0.497	0.499		
					0.465					0.4739								
										0.4749								
M [%]	0.453	0.454	0.455	0.467	0.469	0.470	0.470	0.473	0.475	0.477	0.481	0.481	0.483	0.486	0.497	0.502		0.475
s [%]	0.0030	0.0048	0.0017	0.0019	0.0026	0.0107	0.0094	0.0018	0.0044	0.0030	0.0024	0.0370	0.0033	0.0034	0.0022	0.0042	s_M [%]	0.0142
s_{rel}	0.0067	0.0105	0.0037	0.0041	0.0056	0.0227	0.0200	0.0038	0.0092	0.0063	0.0049	0.0770	0.0069	0.0071	0.0044	0.0083	\bar{s}_i [%]	0.0103
																	0.0298	

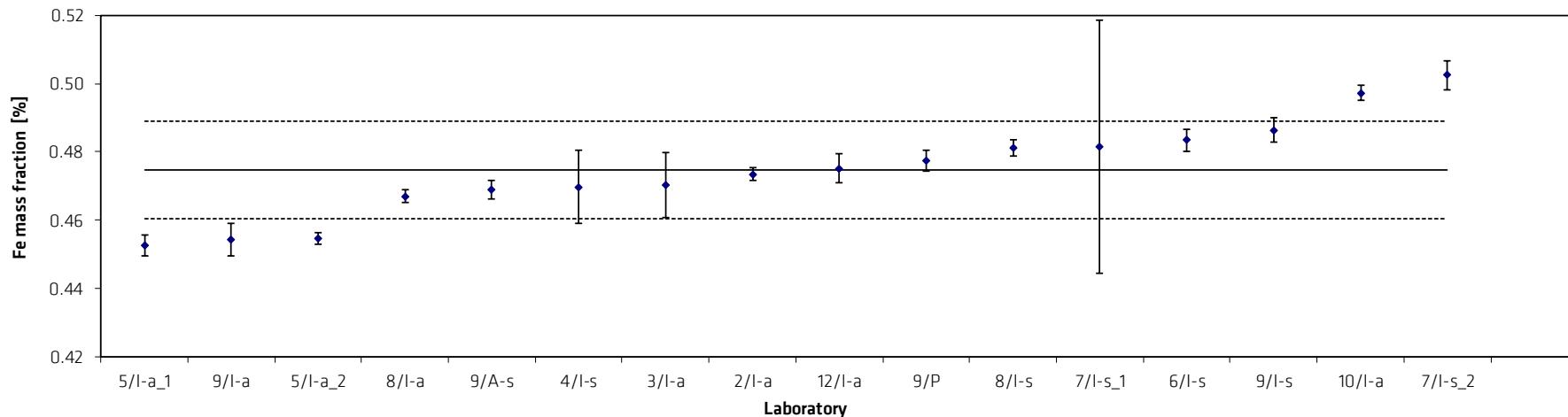


Table 4: Results for Cu

Lab./Meth.	3/I-a	5/I-a_2	7/I-s_1	7/I-s_2	9/I-a	6/I-s	2/I-a	5/I-a_1	10/I-a	8/I-s	4/I-s	12/I-a	8/I-a	9/A-s	9/I-s		
M_i [%]	0.1976	0.196	0.1996	0.1975	0.198	0.1995	0.1994	0.200	0.201	0.1963	0.206	0.202	0.2021	0.2060	0.207		n
	0.1917	0.196	0.1976	0.1956	0.198	0.1993	0.1983	0.201	0.203	0.2127	0.199	0.201	0.2044	0.2049	0.205		15
	0.1948	0.196	0.1967	0.1954	0.201	0.1982	0.1988	0.200	0.201	0.1999	0.202	0.205	0.2038	0.2044	0.206		
	0.1957	0.196	0.2007	0.2006	0.199	0.1990	0.2004	0.199	0.200	0.1998	0.200	0.202	0.2021	0.2034	0.203		
	0.1913	0.197	0.1966	0.1987	0.201	0.1987	0.2010	0.200	0.200	0.1997	0.202	0.199	0.2005	0.2001	0.205		
	0.1889	0.196	0.1940	0.1998	0.195	0.1984	0.2009	0.201	0.200	0.1993	0.200	0.201	0.2011		0.206		
M [%]	0.1933	0.1962	0.1975	0.1979	0.1982	0.1988	0.1998	0.2002	0.2008	0.2013	0.2015	0.2017	0.2023	0.2038	0.2052		0.1999
s [%]	0.0033	0.0003	0.0024	0.0022	0.0024	0.0005	0.0011	0.0009	0.0012	0.0058	0.0025	0.0020	0.0015	0.0022	0.0013	s_M [%]	0.0030
s_{rel}	0.0168	0.0016	0.0121	0.0109	0.0122	0.0025	0.0057	0.0043	0.0058	0.0286	0.0125	0.0098	0.0075	0.0110	0.0064	\bar{s}_i [%]	0.0023
																0.0152	

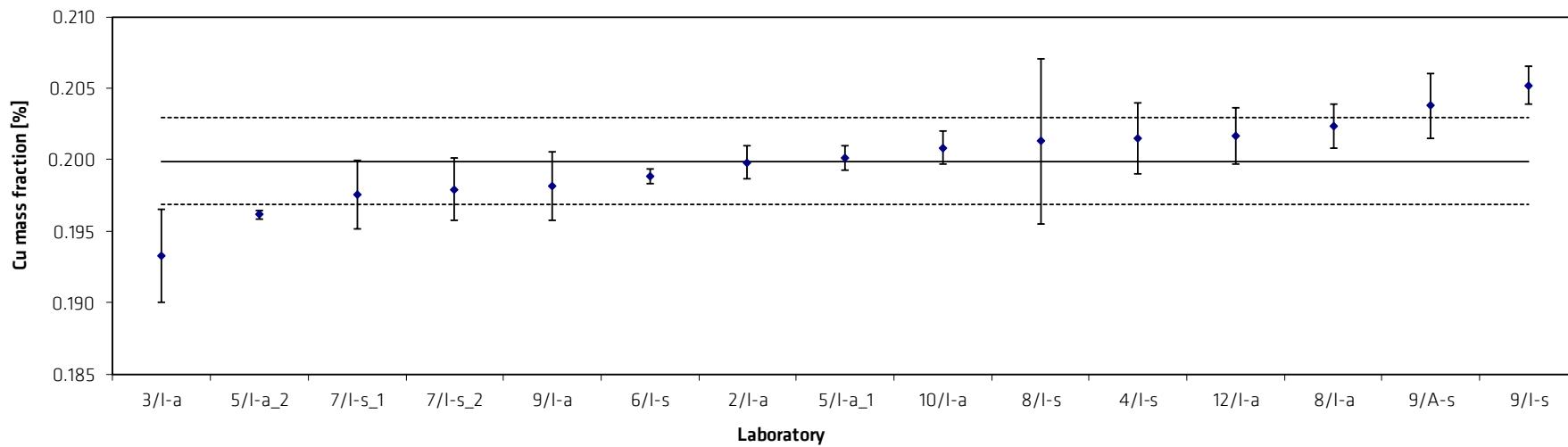


Table 5: Results for Mn

Lab./Meth.	7/I-s_1	9/I-a	9/A-s	8/I-s	5/I-a_2	4/I-s	7/I-s_2	12/I-a	2/I-a	5/I-a_1	8/I-a	9/I-s	9/P	10/I-a	6/I-s	3/I-a		
M_i [%]	1.27	1.282	1.284	1.2862	1.297	1.324	1.306	1.316	1.306	1.308	1.3230	1.340	1.316	1.34	1.337	1.383	n	
	1.26	1.287	1.291	1.2787	1.294	1.307	1.310	1.305	1.303	1.322	1.3365	1.321	1.326	1.34	1.339	1.398		16
	1.26	1.280	1.283	1.2966	1.295	1.305	1.298	1.311	1.307	1.311	1.3328	1.321	1.323	1.34	1.348	1.379		
	1.24	1.278	1.291	1.2977	1.296	1.319	1.293	1.309	1.304	1.313	1.3306	1.311	1.339	1.33	1.346	1.388		
	1.25	1.283	1.291	1.2902	1.295	1.257	1.298	1.288	1.307	1.319	1.3164	1.333	1.334	1.33	1.346	1.376		
	1.25	1.267	1.283	1.2892	1.295	1.270	1.305	1.298	1.304	1.322	1.3198	1.336	1.329	1.33	1.344	1.362		
	1.261	1.269																
M [%]	1.255	1.277	1.284	1.290	1.295	1.297	1.302	1.304	1.305	1.316	1.327	1.327	1.328	1.335	1.343	1.381		1.310
s [%]	0.0105	0.0094	0.0079	0.0070	0.0012	0.0272	0.0063	0.0100	0.0017	0.0060	0.0079	0.0111	0.0081	0.0055	0.0042	0.0119	s_M [%]	0.0298
s_{rel}	0.0084	0.0073	0.0061	0.0054	0.0009	0.0210	0.0049	0.0077	0.0013	0.0045	0.0060	0.0083	0.0061	0.0041	0.0031	0.0087	\bar{s}_i [%]	0.0102
																	0.0228	

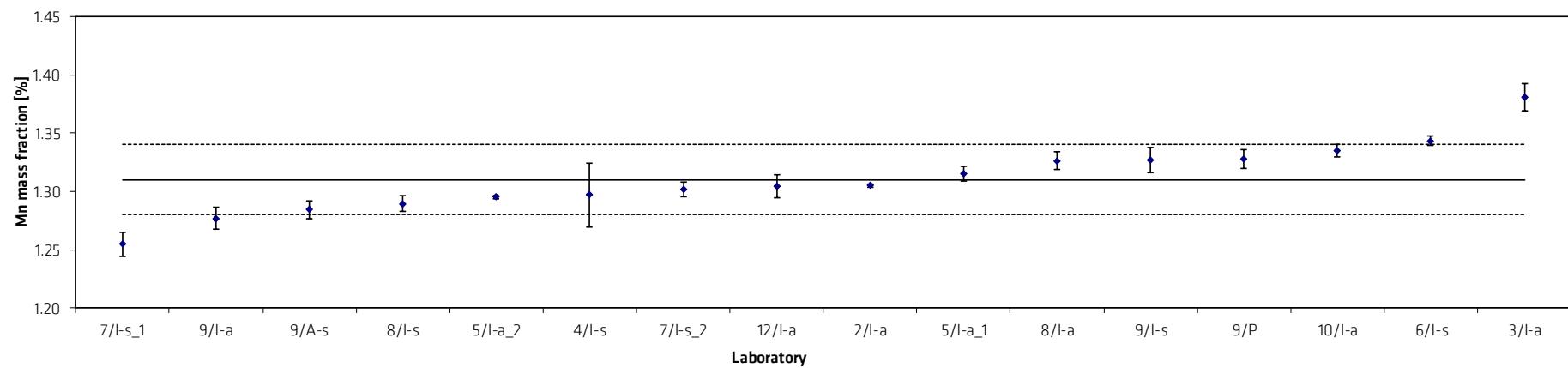


Table 6: Results for Mg

Lab./Meth.	3/I-a	7/I-s_2	9/I-a	5/I-a_2	5/I-a_1	2/I-a	4/I-s	7/I-s_1	12/I-a	9/I-s	8/I-s	8/I-a	9/A-s	10/I-a	6/I-s(R)		
M_i [%]	0.218	0.222	0.218	0.220	0.222	0.224	0.233	0.225	0.226	0.230	0.225	0.233	0.236	0.240	0.244		n
	0.215	0.217	0.219	0.218	0.220	0.223	0.222	0.227	0.227	0.226	0.234	0.235	0.230	0.249	0.244		15
	0.217	0.217	0.222	0.218	0.221	0.224	0.226	0.228	0.226	0.228	0.228	0.235	0.237	0.227	0.244		
	0.220	0.215	0.219	0.219	0.219	0.224	0.223	0.223	0.226	0.227	0.228	0.235	0.232	0.229	0.243		
	0.216	0.216	0.221	0.219	0.219	0.224	0.221	0.224	0.223	0.227	0.226	0.232	0.238	0.231	0.243		
	0.216	0.218	0.217	0.219	0.220	0.224	0.223	0.227	0.226	0.228	0.226	0.233	0.232	0.255	0.244		
			0.215														
M [%]	0.217	0.218	0.219	0.219	0.220	0.224	0.225	0.226	0.226	0.228	0.228	0.234	0.234	0.239	0.244		0.226
s [%]	0.002	0.002	0.002	0.001	0.001	0.001	0.004	0.002	0.001	0.001	0.003	0.001	0.003	0.012	0.001	s_M [%]	0.0081
S_{rel}	0.0081	0.0112	0.0105	0.0023	0.0049	0.0023	0.0196	0.0090	0.0061	0.0059	0.0135	0.0051	0.0141	0.0483	0.0022	\bar{s}_i [%]	0.0036
																	0.0356

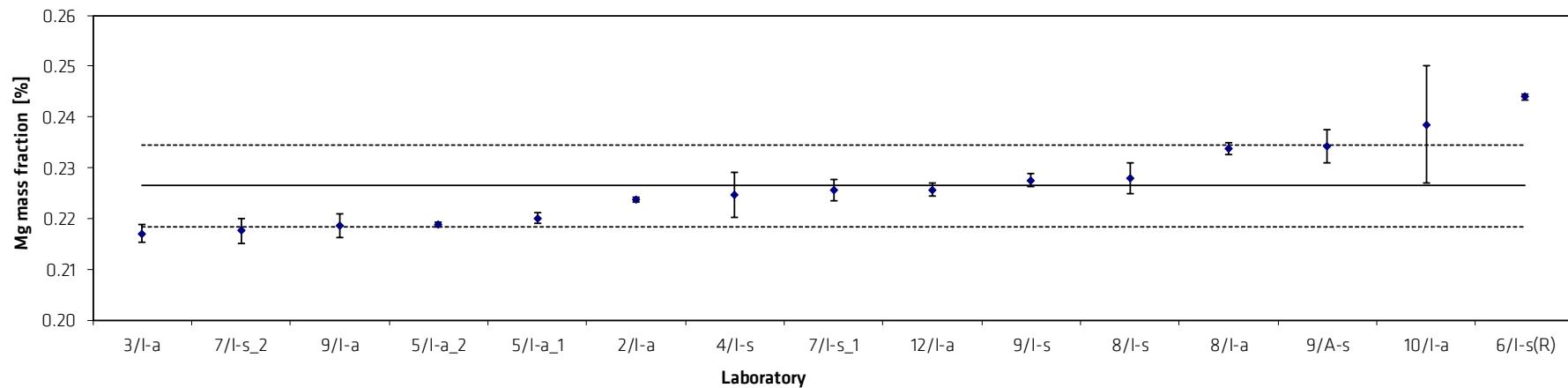


Table 7: Results for Cr

Lab./Meth.	10/I-a	8/I-s	5/I-a_1	9/I-a	8/I-a	6/I-s	4/I-s	2/I-s	12/I-a	5/I-a_2	9/A-s	3/I-a	7/IMS	9/I-s	7/I-s_2(R)	7/I-s_1(R)		
$M_i [\%]$	0.116	0.115	0.1160	0.1169	0.1167	0.1175	0.117	0.1189	0.120	0.1192	0.1196	0.1191	0.1180	0.1217	0.1204	0.1261	n	
	0.116	0.115	0.1165	0.1174	0.1178	0.1175	0.118	0.1187	0.120	0.1196	0.1202	0.1190	0.1210	0.1209	0.1222	0.1281	15	
	0.116	0.1168	0.1168	0.1169	0.1175	0.1173	0.119	0.1189	0.119	0.1198	0.1190	0.1192	0.1180	0.1212	0.1210	0.1297		
	0.116	0.1166	0.1162	0.1165	0.1171	0.1177	0.119	0.1187	0.118	0.1192	0.1190	0.1203	0.1190	0.1193	0.1208	0.1277		
	0.115	0.1163	0.1161	0.1168	0.1163	0.1177	0.118	0.1188	0.117	0.1195	0.1193	0.1222	0.1240	0.1208	0.1229	0.1259		
	0.116	0.1159	0.1155	0.1170	0.1161	0.1177	0.118	0.1186	0.119	0.1192	0.1202	0.1227	0.1230	0.1214	0.1208	0.1253		
				0.1149						0.1182								
$M [\%]$	0.1158	0.1161	0.1162	0.1166	0.1169	0.1176	0.1182	0.1188	0.1188	0.1193	0.1195	0.1204	0.1205	0.1209	0.1214	0.1271		0.1185
$s [\%]$	0.0004	0.0006	0.0004	0.0008	0.0007	0.0002	0.0008	0.0001	0.0012	0.0002	0.0007	0.0016	0.0026	0.0008	0.0010	0.0017	$s_M [\%]$	0.0019
s_{rel}	0.00352	0.00478	0.00381	0.00693	0.00574	0.00130	0.00637	0.00103	0.00984	0.00189	0.00593	0.01370	0.02148	0.00687	0.00804	0.01306	$\bar{s}_i [\%]$	0.0010
																	0.01572	

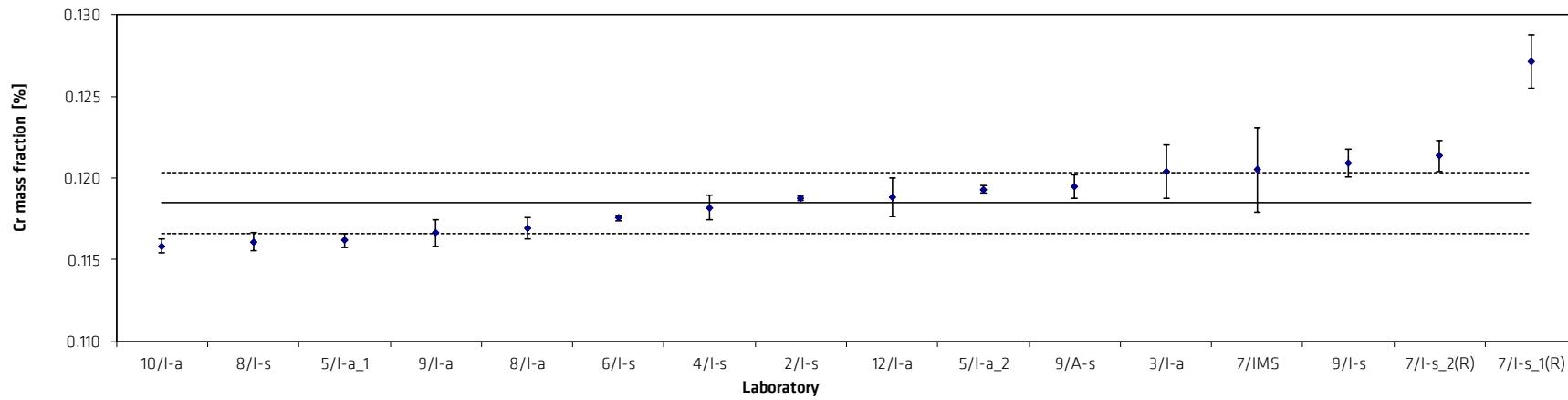


Table 8: Results for Ni

Lab./Meth.	8/I-a	9/I-a	5/I-a_1	9/I-s	8/I-s	7/IMS	5/I-a_2	3/I-a	6/I-s	12/I-a	2/IMS-s	7/I-s_1(R)	10/I-a	4/I-s	7/I-s_2		
M_i [%]	0.0279	0.0296	0.0289	0.0291	0.0288	0.0307	0.0290	0.0293	0.0293	0.0297	0.0292	0.0298	0.0297	0.0285	0.0300	n	
	0.0282	0.0286	0.0287	0.0288	0.0289	0.0285	0.0289	0.0285	0.0294	0.0293	0.0296	0.0300	0.0301	0.0294	0.0300	14	
	0.0282	0.0285	0.0288	0.0288	0.0289	0.0290	0.0288	0.0288	0.0293	0.0294	0.0294	0.0300	0.0297	0.0298	0.0299		
	0.0280	0.0278	0.0287	0.0286	0.0288	0.0277	0.0291	0.0301	0.0294	0.0294	0.0297	0.0297	0.0295	0.0299	0.0301		
	0.0279	0.0285	0.0286	0.0289	0.0286	0.0297	0.0293	0.0286	0.0294	0.0291	0.0297	0.0292	0.0297	0.0308	0.0300		
	0.0278	0.0294	0.0289	0.0289	0.0294	0.0287	0.0293	0.0291	0.0295	0.0295	0.0297	0.0292	0.0296	0.0300	0.0300		
M [%]	0.0280	0.0287	0.0288	0.0289	0.0289	0.0291	0.0291	0.0291	0.0294	0.0294	0.0295	0.0297	0.0297	0.0300		0.0293	
s [%]	0.0002	0.0006	0.0001	0.0002	0.0003	0.0010	0.0002	0.0006	0.0001	0.0002	0.0002	0.0004	0.0002	0.0008	0.0001	s_M [%]	0.00041
s_{rel}	0.0060	0.0197	0.0042	0.0061	0.0093	0.0358	0.0057	0.0203	0.0027	0.0068	0.0069	0.0124	0.0069	0.0255	0.0021	s_i [%]	0.00043
																0.0141	

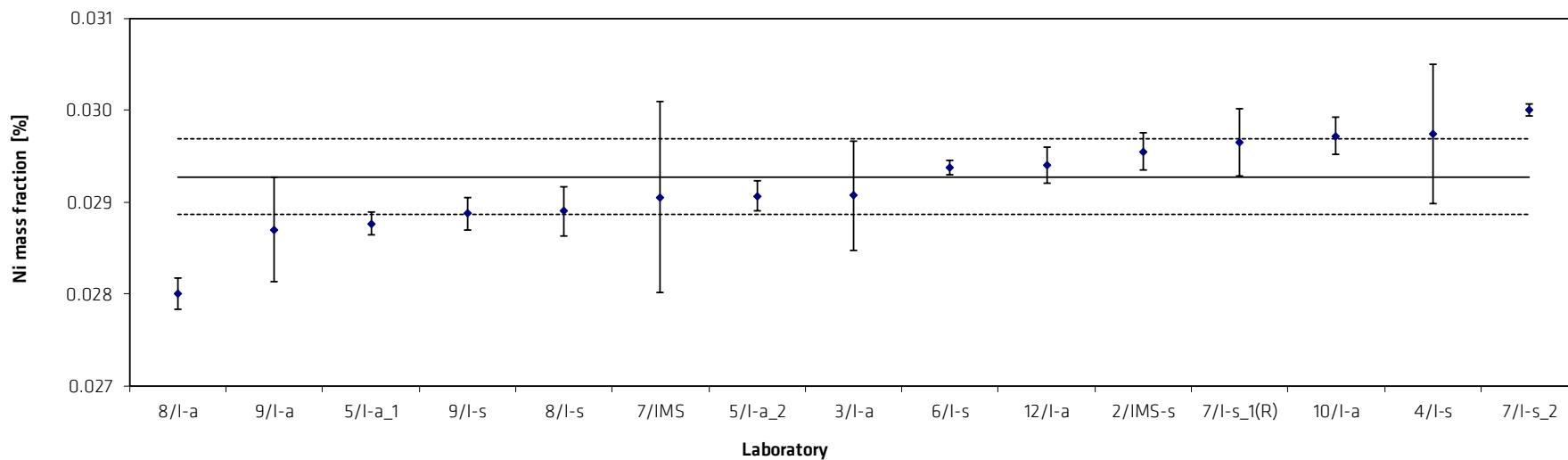


Table 9: Results for Zn

Lab./Meth.	5/I-a_1	9/I-a	2/I-a	7/I-s_1	4/I-s	10/I-a	8/I-a	8/I-s	6/I-s	12/I-a	5/I-a_2	7/I-s_2	9/A-s	9/I-s	3/I-a		
M_i [%]	0.104	0.1030	0.1034	0.1058	0.107	0.105	0.1049	0.1049	0.1052	0.105	0.110	0.1062	0.1074	0.1092	0.1066		n
	0.103	0.1031	0.1041	0.1032	0.103	0.105	0.1053	0.1043	0.1054	0.106	0.105	0.1067	0.1075	0.1077	0.1064		15
	0.104	0.1039	0.1042	0.0996	0.106	0.104	0.1047	0.1051	0.1059	0.105	0.105	0.1065	0.1062	0.1077	0.1066		
	0.104	0.1036	0.1044	0.1062	0.103	0.104	0.1050	0.1051	0.1050	0.105	0.104	0.1056	0.1064	0.1062	0.1102		
	0.103	0.1047	0.1042	0.1037	0.105	0.104	0.1038	0.1042	0.1050	0.106	0.105	0.1055	0.1066	0.1073	0.1093		
	0.104	0.1034	0.1041	0.1067	0.103	0.105	0.1041	0.1045	0.1049	0.105	0.105	0.1065	0.1076	0.1081	0.1107		
M [%]	0.1036	0.1036	0.1041	0.1042	0.1045	0.1045	0.1046	0.1047	0.1052	0.1053	0.1055	0.1062	0.1069	0.1077	0.1083		0.1053
s [%]	0.0004	0.0006	0.0003	0.0027	0.0018	0.0005	0.0006	0.0004	0.0004	0.0005	0.0022	0.0005	0.0006	0.0010	0.0020	s_M [%]	0.0014
s_{rel}	0.0041	0.0060	0.0032	0.0255	0.0168	0.0052	0.0055	0.0038	0.0036	0.0049	0.0211	0.0048	0.0053	0.0091	0.0184	\bar{s}_i [%]	0.0012
																	0.0136

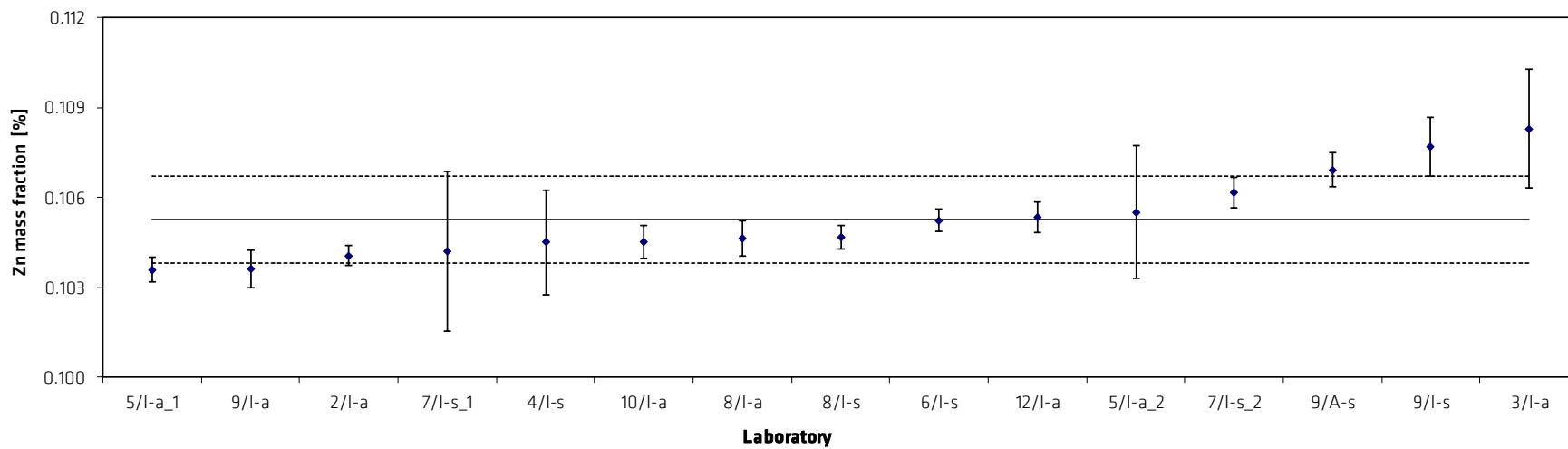


Table 10: Results for Ti

Lab./Meth.	7/I-s_2	5/I-a_1	5/I-a_2	2/I-s	9/I-s	8/I-s	6/I-s	3/I-a	7/I-s_1	12/I-a	9/I-a	10/I-a	9/P	4/I-s	8/I-a		
M_i [%]	0.0272	0.0271	0.0275	0.0276	0.0277	0.0274	0.0280	0.0278	0.0293	0.0282	0.0296	0.0282	0.0284	0.0289	0.0288		n
	0.0271	0.0273	0.0276	0.0275	0.0278	0.0277	0.0278	0.0281	0.0287	0.0284	0.0285	0.0284	0.0285	0.0280	0.0292		15
	0.0271	0.0274	0.0275	0.0276	0.0277	0.0278	0.0278	0.0276	0.0292	0.0282	0.0274	0.0278	0.0278	0.0291	0.0290		
	0.0269	0.0274	0.0276	0.0277	0.0277	0.0277	0.0277	0.0277	0.0266	0.0282	0.0276	0.0278	0.0282	[0.0304]	0.0287		
	0.0274	0.0276	0.0275	0.0277	0.0277	0.0278	0.0277	0.0280	0.0269	0.0272	0.0278	0.0279	0.0283	0.0289	0.0283		
	0.0277	0.0272	0.0275	0.0276	0.0274	0.0276	0.0277	0.0282	0.0269	0.0279	0.0283	0.0285	0.0280	0.0281	0.0284		
M [%]	0.0272	0.0273	0.0275	0.0276	0.0277	0.0277	0.0278	0.0279	0.0279	0.0280	0.0281	0.0281	0.0282	0.0286	0.0287		0.0279
s [%]	0.00028	0.00020	0.00005	0.00006	0.00013	0.00015	0.00009	0.00025	0.00126	0.00043	0.00081	0.00031	0.00024	0.00051	0.00034	s_M [%]	0.00042
s_{rel}	0.0103	0.0072	0.0019	0.0022	0.0047	0.0054	0.0034	0.0090	0.0452	0.0154	0.0288	0.0110	0.0087	0.0178	0.0120	s_i [%]	0.00046
																	0.0150

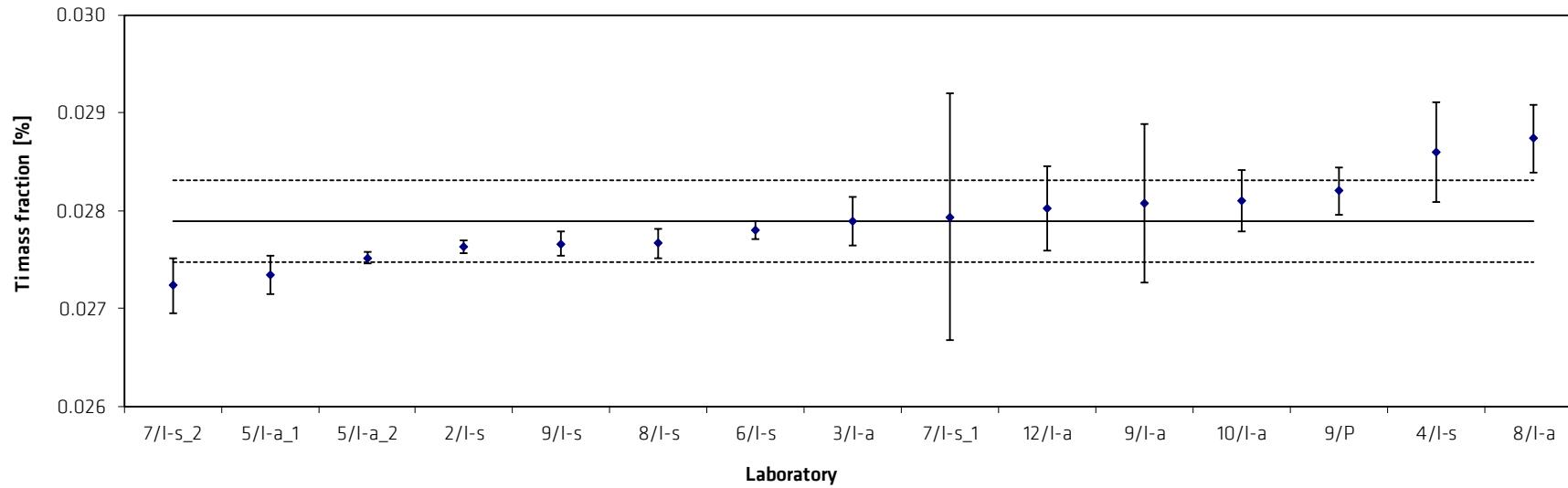


Table 11: Results for B

Lab./Meth.	9/I-s	8/I-s	2/IMS-s	6/I-s	7/IMS-s	4/I-s	3/I-s		
M_i [mg/kg]	2.4	3	3.42	4.4	4.0	5.0	< 6		n 6
	2.3	3	3.92	3.1	3.9	5.1	< 6		
	2.4	3	3.30	2.4	4.0	4.9	< 6		
	2.3	3	3.83	3.8	3.8	5.0	< 6		
	2.3	3	3.54	2.4	3.9	5.5	< 6		
	2.4	3	3.02	5.8	3.6	5.5	< 6		
M [mg/kg]	2.36	3.00	3.51	3.65	3.86	5.17	< 6		3.59
s [mg/kg]	0.063	0.000	0.334	1.322	0.117	0.266		s_M [mg/kg]	0.941
s_{rel}	0.027	0.000	0.095	0.362	0.030	0.051		\bar{s}_i [mg/kg]	0.528
									0.262

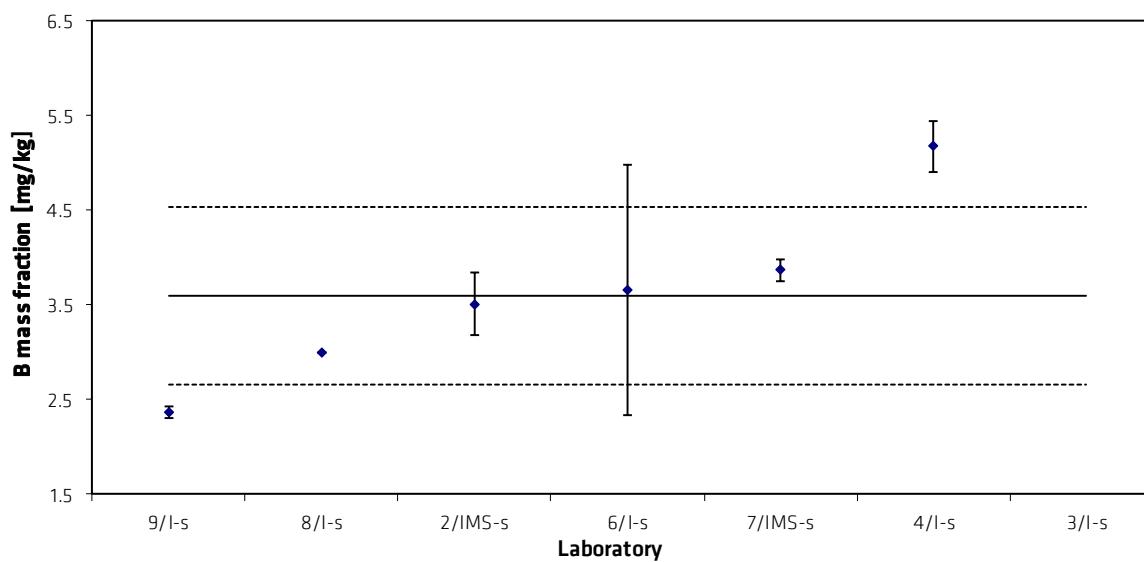


Table 12: Results for Be

Lab./Meth.	9/I-s	7/I-s_2	10/I-a	9/I-a	4/I-s	6/I-a	5/I-a_1	5/I-a_2	2/IMS-s	12/I-a	3/I-a		
M_i [mg/kg]	6.84	7.2	7.0	7.30	7.1	7.25	7.29	7.31	7.31	7.5	7.3		n
	6.80	6.9	7.1	7.10	7.1	7.29	7.29	7.27	7.38	7.4	7.3		11
	6.79	6.8	7.1	7.20	7.0	7.21	7.25	7.30	7.25	7.4	7.3		
	6.74	7.1	7.0	7.00	6.7	7.24	7.26	7.33	7.36	7.2	7.7		
	6.82	7.0	7.1	7.10	7.7	7.26	7.22	7.36	7.35	7.4	7.3		
	6.84	6.8	7.1	7.30	7.3	7.26	7.33	7.35	7.37	7.4	7.7		
				7.10									
				7.00									
M [mg/kg]	6.81	6.95	7.07	7.14	7.15	7.25	7.27	7.32	7.34	7.38	7.43		7.19
s [mg/kg]	0.039	0.138	0.052	0.119	0.333	0.028	0.038	0.033	0.050	0.098	0.207	s_M [mg/kg]	0.193
S_{rel}	0.006	0.020	0.007	0.017	0.047	0.004	0.005	0.005	0.007	0.013	0.028	\bar{s}_i [mg/kg]	0.137
													0.027

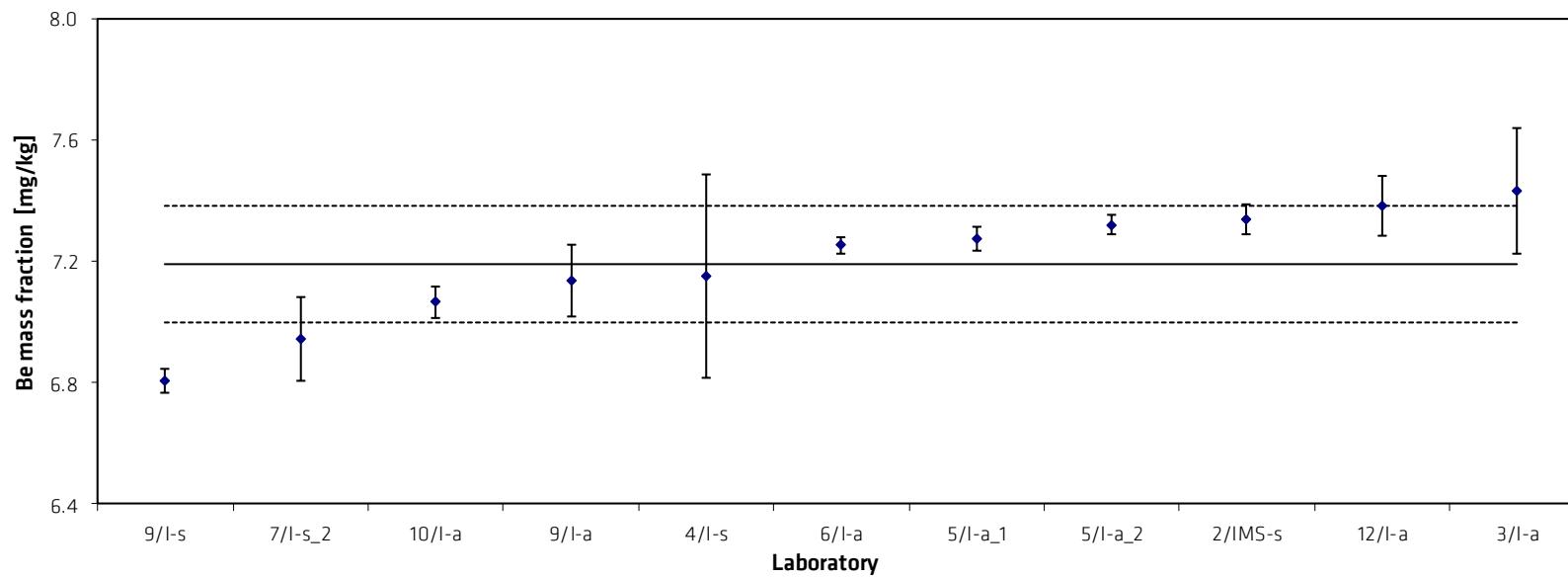


Table 13: Results for Bi

Lab./Meth.	8/I-s	5/I-a_2	10/I-a	7/I-s_2	7/I-s_1	2/IMS-s	12/I-a	4/I-s	9/I-s	7/IMS-s	5/I-a_1	6/I-s		
M_i [mg/kg]	69	72.9	73.3	77.0	77.4	74.7	74.2	73.3	78.3	74.7	78.7	79.9		n
	69	73.0	75.7	79.9	79.1	76.5	76.1	73.8	76.6	76.2	78.9	80.2		11
	69	74.3	77.1	78.1	75.9	75.9	78.2	76.9	77.2	77.2	77.3	80.1		
	69	72.8	76.6	72.2	75.7	76.7	76.2	77.4	76.8	82.4	77.3	79.3		
	69	74.9	75.5	73.3	73.9	76.6	75.7	78.8	77.1	76.5	75.8	78.3		
	69	73.0	77.3	75.3	73.8	76.1	76.3	76.9	77.6	78.1	77.5	77.8		
M [mg/kg]	69.0	73.5	75.9	75.9	76.0	76.1	76.1	76.2	77.3	77.5	77.6	79.3		76.5
s [mg/kg]	0.00	0.90	1.47	2.93	2.05	0.73	1.28	2.16	0.60	2.65	1.11	1.00	s_M [mg/kg]	1.45
s_{rel}	0.000	0.012	0.019	0.039	0.027	0.010	0.017	0.028	0.008	0.034	0.014	0.013	\bar{s}_i [mg/kg]	1.71
													s_{rel}	0.019

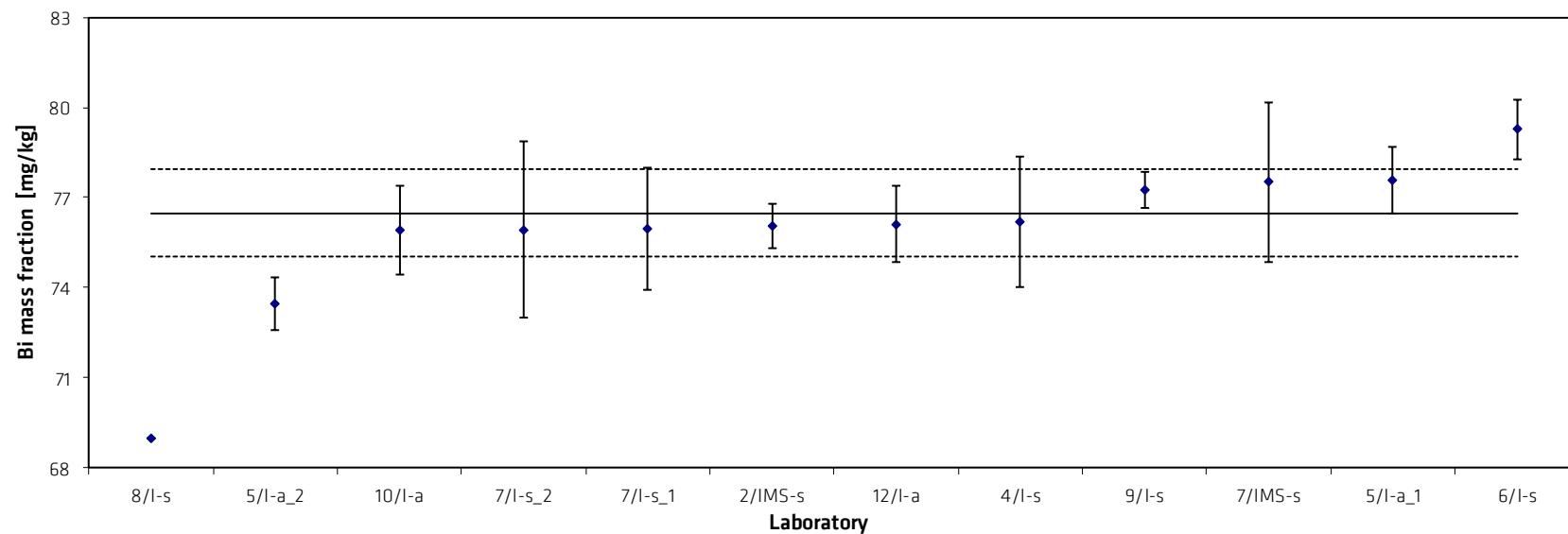


Table 14: Results for Ca

Lab./Meth.	7/I-s_2(R)	6/I-s	12/I-a	4/I-s	7/I-s_1(R)	2/I-s		
M_i [mg/kg]	18.7 19.1 18.7 18.7 18.3 19.5	19.9 19.4 19.2 18.1 20.7 17.8	19.9 19.2 21.3 20.6 18.4 19.6	20.4 20.0 19.4 19.0 20.8 20.4	19.00 19.80 19.80 21.40 20.20 21.90	20.6 21.2 20.7 21.5 21.6 21.4		n 6
M [mg/kg]	18.9	19.4	19.8	20.0	20.4	21.2		19.9
s [mg/kg]	0.41	1.21	1.03	0.68	1.09	0.44	s_M [mg/kg] \bar{s}_i [mg/kg]	0.79 0.87 0.040
S_{rel}	0.022	0.062	0.052	0.034	0.054	0.021		

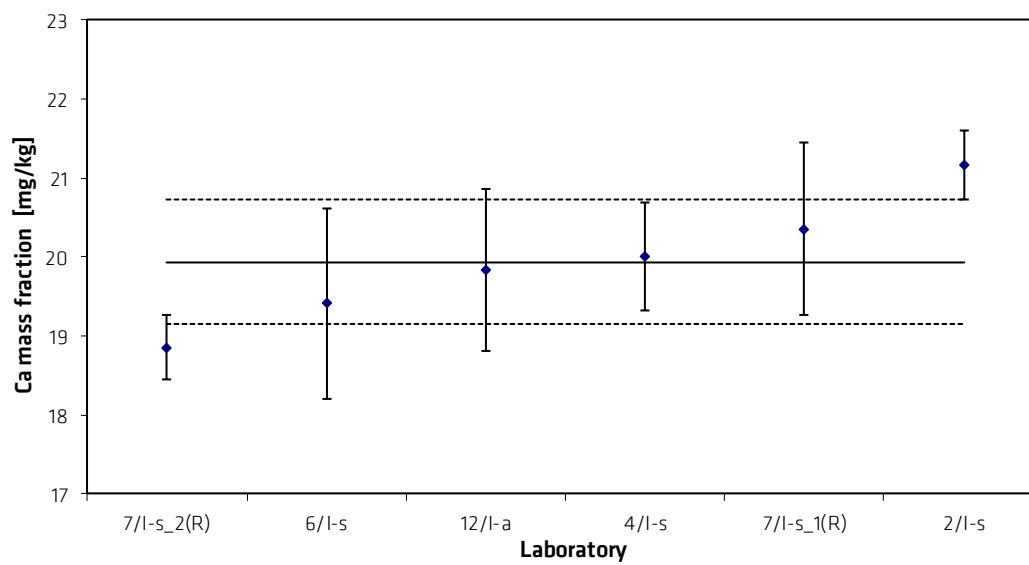


Table 15: Results for Cd

Lab./Meth.	4/I-s	7/I-s_1	9/I-a	5/I-a_2	9/I-s	7/I-s_2	2/I-s	12/I-a	7/IMS	6/I-s	10/I-a	5/I-a_1	8/I-s		
M_i [mg/kg]	9.8 9.6 9.4 9.4 10.0 9.5	9.8 9.6 9.5 10.0 9.7 10.0	10.2 9.9 9.9 10.0 9.6 9.9	10.1 10.2 10.0 10.1 9.6 10.0	10.1 10.1 10.1 9.9 9.9 10.0	10.9 9.9 10.0 9.5 9.9 9.9	10.4 10.4 10.5 9.5 10.2 9.9	10.3 10.3 10.0 10.1 10.0 10.2	9.9 10.1 10.3 10.3 10.3 10.5	10.3 10.3 10.4 10.4 10.3 10.3	10.5 10.6 10.5 10.5 10.4 10.5	11.5 11.5 11.4 11.4 11.4 11.5	12 12 12 12 12 12	n 11	
M [mg/kg]	9.62	9.77	9.89	10.04	10.04	10.08	10.15	10.15	10.24	10.34	10.50	11.46	12.00		10.07
s [mg/kg]	0.24	0.21	0.21	0.09	0.06	0.40	0.39	0.14	0.19	0.04	0.06	0.08	0.00	s_M [mg/kg] \bar{s}_i [mg/kg]	0.25 0.22
s_{rel}	0.0250	0.0211	0.0209	0.0089	0.0061	0.0401	0.0384	0.0136	0.0189	0.0039	0.0060	0.0068	0.0000		0.0249

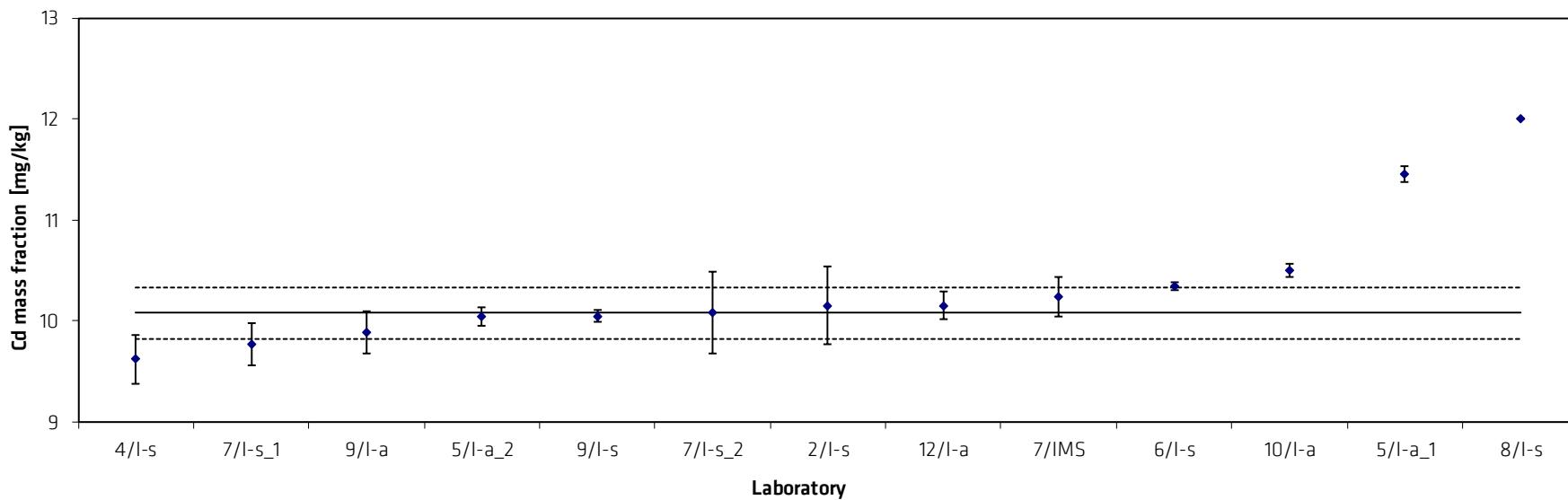


Table 16: Results for Co

Lab./Meth.	9/I-s	4/I-s	12/I-a	7/I-s_1	10/I-a	2/I-s	7/IMS	7/I-s_2	6/I-s	8/I-s	5/I-a_2	5/I-a_1		
M_i [mg/kg]	9.2	9.0	9.3	9.6	9.4	9.5	9.7	9.8	9.6	10	10.2	10.8		n
	9.1	9.0	9.4	9.3	9.3	9.6	9.5	9.9	9.8	10	10.4	10.7		12
	9.1	8.9	9.5	9.7	9.4	9.5	9.4	9.7	10.2	10	10.5	10.6		
	9.1	8.9	9.4	9.4	9.4	9.6	9.8	9.8	9.9	10	10.6	10.6		
	9.1	9.7	9.2	9.2	10.0	9.8	9.7	10.0	10.0	10	10.6	10.5		
	9.2	9.5	9.4	9.1	9.0	9.8	9.7	9.9	10.0	10	10.5	10.6		
M [mg/kg]	9.13	9.17	9.37	9.38	9.42	9.63	9.63	9.85	9.91	10.00	10.46	10.64		9.72
s [mg/kg]	0.07	0.34	0.10	0.23	0.33	0.12	0.15	0.09	0.20	0.00	0.18	0.09	s_M [mg/kg]	0.48
s_{rel}	0.0075	0.0376	0.0110	0.0247	0.0345	0.0123	0.0157	0.0087	0.0199	0.0000	0.0169	0.0081	\bar{s}_i [mg/kg]	0.19
														0.0493

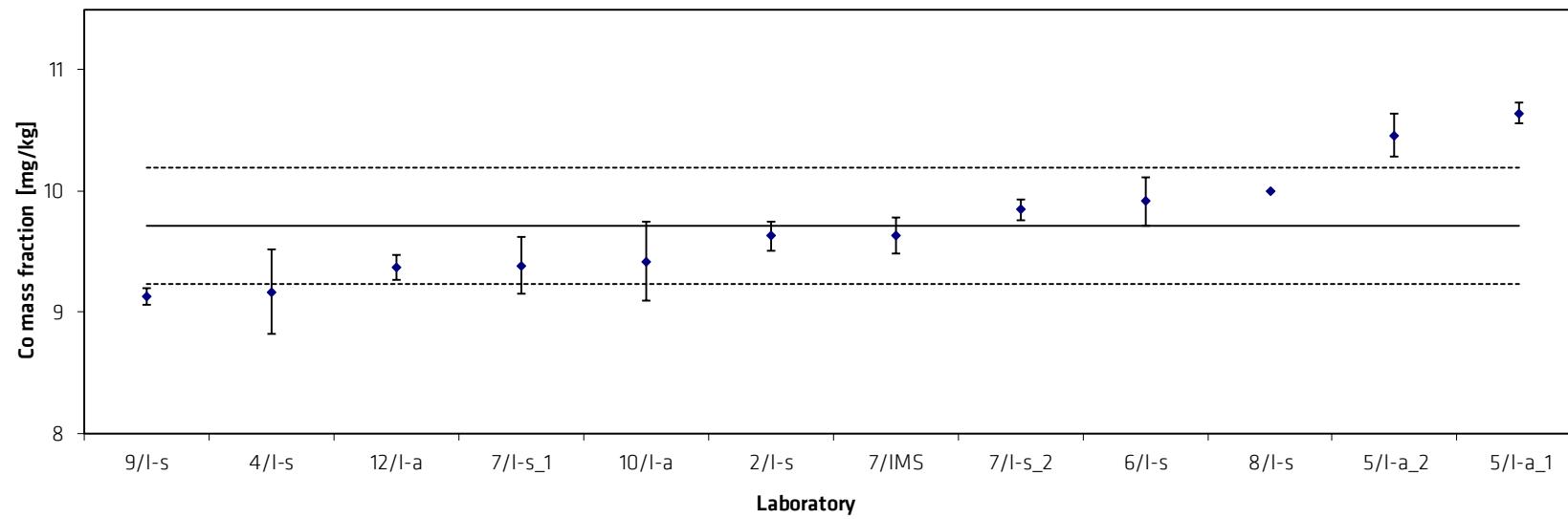


Table 17: Results for Ga

Lab./Meth.	2/IMS-s	7/IMS	7/I-s_1	4/I-s	5/I-a_2	5/I-a_1	12/I-a(R)	9/I-s	10/I-a(R)	7/I-s_2	3/I-s	6/I-a		
M_i [mg/kg]	53.2	53.6	54.0	53.4	55.5	55.3	55.0	59.2	57.5	59.7	73.0	66.0		n
	53.1	52.2	54.0	53.3	54.0	56.3	56.0	58.3	59.1	60.0	62.0	67.6		12
	52.8	52.1	53.0	52.8	54.5	55.8	59.0	58.7	59.9	59.9	70.3	66.1		
	53.4	53.8	53.0	54.1	55.2	55.9	55.0	58.3	59.3	59.7	68.7	66.6		
	52.5	54.1	55.0	56.4	54.6	55.6	59.0	58.6	61.5	59.9	62.0	66.5		
	52.2	53.4	53.0	54.8	54.4	57.8	58.0	58.9	60.0	60.2	62.3	66.9		
M [mg/kg]	52.9	53.2	53.7	54.1	54.7	56.1	57.0	58.7	59.6	59.9	66.4	66.6		57.7
s [mg/kg]	0.45	0.85	0.82	1.31	0.54	0.88	1.90	0.35	1.31	0.19	4.89	0.57	s_M [mg/kg]	4.75
s_{rel}	0.009	0.016	0.015	0.024	0.010	0.016	0.033	0.006	0.022	0.003	0.074	0.009	\bar{s}_i [mg/kg]	1.69
													s_{rel}	0.082

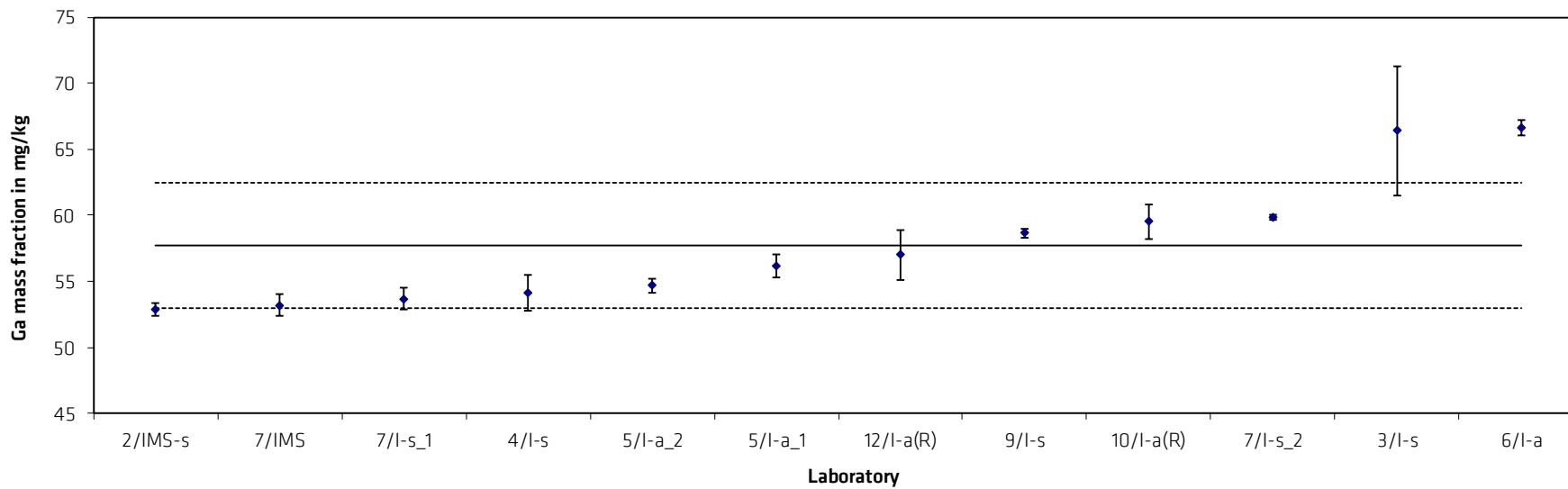
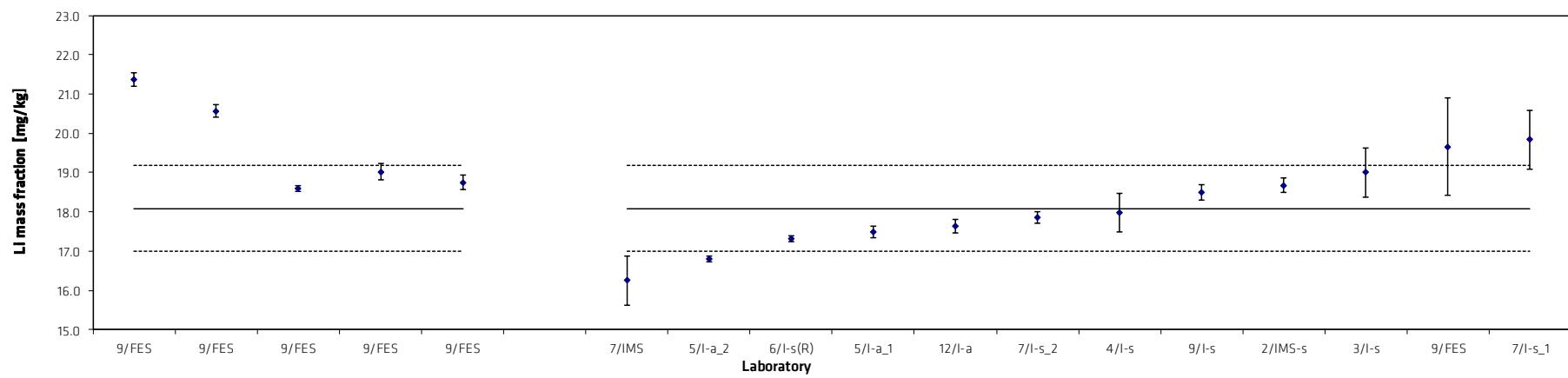


Table 18: Results for Li

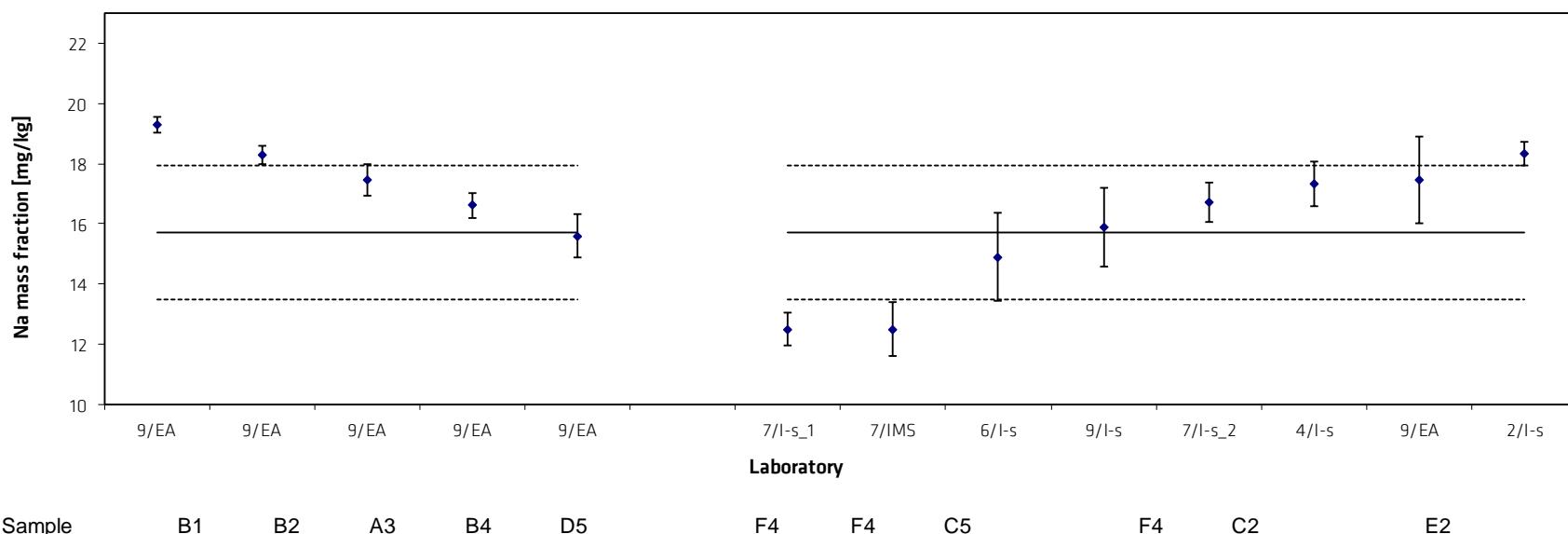
Lab./Meth.	9/FES	9/FES	9/FES	9/FES	9/FES		7/IMS	5/I-a_2	6/I-s(R)	5/I-a_1	12/I-a	7/I-s_2	4/I-s	9/I-s	2/IMS-s	3/I-s	9/FES	7/I-s_1			
M_i [mg/kg]	21.2	20.4	18.5	18.8	18.7			16.2	16.8	17.3	17.5	17.8	18.3	18.8	18.6	19	21.4	20.0		n	
	21.3	20.4	18.6	18.9	18.6			16.4	16.7	17.2	17.6	17.5	17.7	18.1	18.5	18.7	19	20.6	20.0	12	
	21.4	20.6	18.6	19.2	18.8			15.3	16.8	17.4	17.3	17.8	17.8	17.2	18.5	18.4	19	18.6	20.0		
	21.6	20.8	18.7	19.2	19.0			16.0	16.9	17.2	17.7	17.7	17.9	17.6	18.2	18.6	20	19.0	19.0		
								17.2	16.9	17.4	17.5	17.4	17.8	18.5	18.5	18.9	18	18.8	19.0		
								16.4	16.7	17.3	17.4	17.5	18.1	18.2	18.5	18.8	19		21.0		
M [mg/kg]	21.4	20.6	18.6	19.0	18.8			16.3	16.8	17.3	17.5	17.6	17.9	18.0	18.5	18.7	19.0	19.7	19.8		18.1
s [mg/kg]	0.18	0.16	0.08	0.20	0.18			0.62	0.08	0.07	0.15	0.16	0.14	0.49	0.20	0.18	0.63	1.23	0.75	s_M [mg/kg]	
s_{rel}	0.008	0.008	0.004	0.011	0.010			0.038	0.005	0.004	0.008	0.009	0.008	0.027	0.011	0.010	0.033	0.063	0.038	\bar{s}_M [mg/kg]	
																				0.34	
																				0.060	



Sample B1 B2 A3 B4 D5 F4 D4 C5 D4 E3 F4 C2 E2 E5 F4

Table 19: Results for Na

Lab./Meth.	9/EA	9/EA	9/EA	9/EA	9/EA		7/I-s_1	7/IMS	6/I-s	9/I-s	7/I-s_2	4/I-s	9/EA	2/I-s		
M_i [mg/kg]	19.4	18.3	17.2	16.2	16.4		13.0	11.6	13.8	15.3	15.6	16.7	19.3	17.8		n
	19.3	18.5	17.8	16.9	16.0		13.0	12.3	17.2	15.6	16.3	17.4	18.3	18.1		8
	19.5	18.4	18.0	16.4	14.8		13.0	11.4	14.1	15.1	17.3	16.8	17.5	18.3		
	18.9	17.8	16.8	17.0	15.2		12.0	13.0	15.9	15.5	16.8	16.7	16.6	18.7		
							12.0	13.6	15.1	15.3	17.4	18.4	15.6	18.8		
							12.0	13.1	13.3	18.5	16.9	18.0		18.2		
M [mg/kg]	19.3	18.3	17.5	16.6	15.6		12.5	12.5	14.9	15.9	16.7	17.3	17.5	18.3		15.7
s [mg/kg]	0.26	0.30	0.54	0.41	0.72		0.55	0.88	1.47	1.31	0.66	0.73	1.44	0.39	s_M [mg/kg]	2.23
s_{rel}	0.013	0.016	0.031	0.025	0.046		0.044	0.070	0.099	0.083	0.039	0.042	0.082	0.021	\bar{s}_i [mg/kg]	0.78
																0.142



Sample B1 B2 A3 B4 D5 F4 F4 C5 F4 C2 E2

Table 20: Results for Pb

Lab./Meth.	3/I-a	5/I-a_1	6/I-s	2/IMS-s	7/IMS	4/I-s	7/I-s_1	12/I-a	7/I-s_2	9/I-s	5/I-a_2		
M_i [mg/kg]	87	87.6	88.7	90.3	87.0	90.8	98.0	93.7	97.3	97.3	98.7		n
	87	86.8	89.3	92.2	88.8	91.2	93.0	95.8	96.3	95.7	98.3		10
	91	92.0	89.9	90.7	90.0	89.1	92.0	91.6	98.2	97.0	101.8		
	91	88.5	90.4	89.4	97.8	93.4	91.0	92.9	90.8	96.3	107.2		
	89	89.8	90.9	91.0	89.4	93.8	92.1	94.4	94.8	96.4	104.8		
	87	90.8	89.8	89.7	91.2	91.9	92.9	93.7	95.6	97.3	105.2		
M [mg/kg]	88.7	89.3	89.8	90.5	90.7	91.7	93.2	93.7	95.5	96.7	102.7		92.0
s [mg/kg]	1.97	1.96	0.80	1.02	3.75	1.74	2.48	1.41	2.60	0.66	3.67	s_M [mg/kg]	2.69
s_{rel}	0.0222	0.0219	0.0089	0.0113	0.0413	0.0190	0.0266	0.0151	0.0272	0.0068	0.0357	\bar{s}_i [mg/kg]	2.04
												s_{rel}	0.029

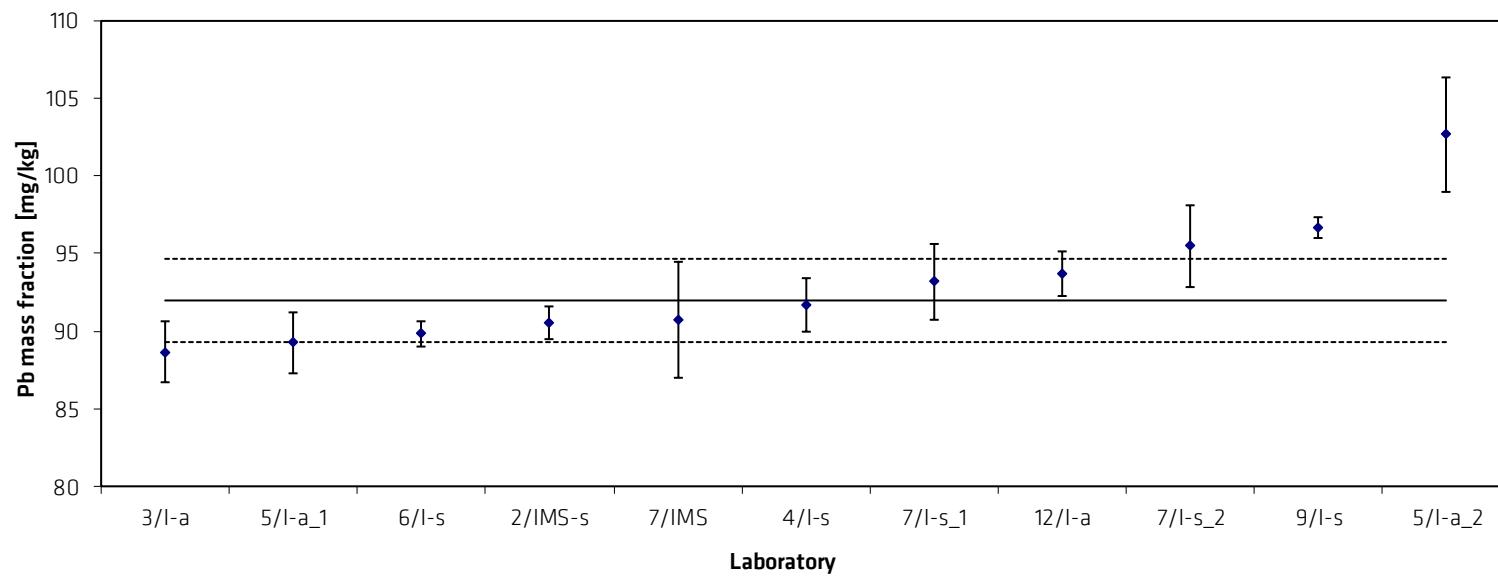


Table 21: Results for Sn

Lab./Meth.	9/I-s	3/I-a	10/I-a	12/I-a	6/I-s	7/I-s_1	5/I-a_2	2/IMS-s	4/I-s	9/I-a	5/I-a_1	7/I-s_2	7/IMS		
M_i [mg/kg]	93.7	98	96.7	97.2	97.3	105	97.2	98.7	95.2	99.0	98.9	99.2	101.0		n
	93.3	93	96.6	97.6	97.6	96	99.4	99.0	98.1	99.9	99.7	97.8	102.0		13
	93.2	93	95.8	97.2	97.3	99	98.9	98.5	96.6	97.0	100.1	99.9	102.0		
	93.0	98	93.9	96.8	96.7	98	96.7	97.8	101.4	100.0	97.8	101.6	109.0		
	93.0	88	95.2	96.0	96.8	93	100.1	98.8	97.8	97.8	97.9	103.6	102.0		
	93.5	90	96.3	96.0	96.8	95	96.3	97.5	101.6	100.5	99.3	99.8	103.0		
M [mg/kg]	93.3	93.3	95.8	96.8	97.1	97.7	98.1	98.4	98.5	98.7	98.9	100.3	103.2		97.7
s [mg/kg]	0.29	4.08	1.06	0.67	0.35	4.18	1.57	0.59	2.58	1.59	0.94	2.02	2.93	s_M [mg/kg]	2.64
s_{rel}	0.003	0.044	0.011	0.007	0.004	0.043	0.016	0.006	0.026	0.016	0.009	0.020	0.028	\bar{s}_i [mg/kg]	2.17
															0.027

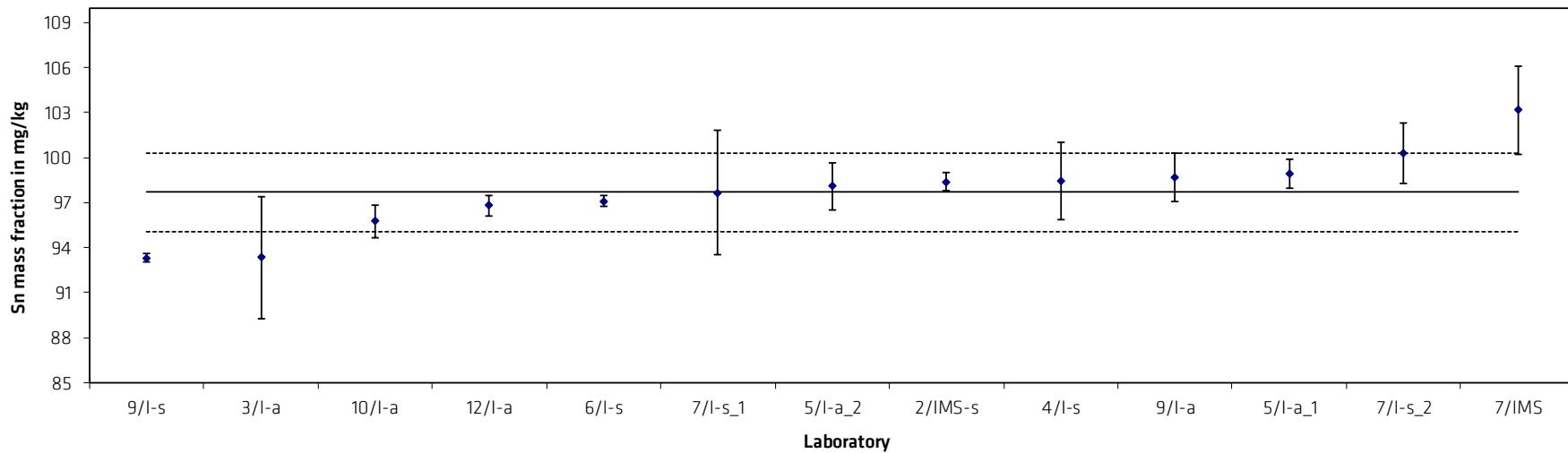


Table 22: Results for V

Lab./Meth.	10/I-a	5/I-a_1	4/I-s	9/I-s	2/I-a	7/I-s_2	12/I-a	6/I-s	3/I-a	9/P	5/I-a_2	7/I-s_1	7/IMS		
M_i [mg/kg]	113	112.8	109.4	115.1	114.3	113.6	115.8	114.2	113.3	116.9	115.8	125.0	123.0		n
	113	113.3	110.3	114.1	114.3	114.5	114.9	115.0	114.0	117.7	115.9	124.0	129.0		11
	112	114.2	118.1	114.4	113.9	114.4	115.0	115.1	114.3	114.7	115.1	124.0	125.0		
	112	111.9	115.4	113.4	113.9	113.4	115.0	114.9	113.7	112.0	116.0	123.0	127.0		
	111	112.4	118.3	113.0	114.4	114.4	112.0	114.1	116.7	116.5	115.1	124.0	130.0		
	113	111.1	110.5	114.1	114.0	114.5	113.2	114.2	116.7	114.4	115.5	123.0	131.0		
M [mg/kg]	112.3	112.6	113.7	114.0	114.1	114.1	114.3	114.6	114.8	115.4	115.6	123.8	127.5		114.1
s [mg/kg]	0.8	1.1	4.1	0.7	0.2	0.5	1.4	0.5	1.5	2.1	0.4	0.8	3.1	s_M [mg/kg]	1.00
s_{rel}	0.007	0.010	0.036	0.007	0.002	0.004	0.012	0.004	0.013	0.018	0.003	0.006	0.024	\bar{s}_i [mg/kg]	1.72
														s_{rel}	0.009

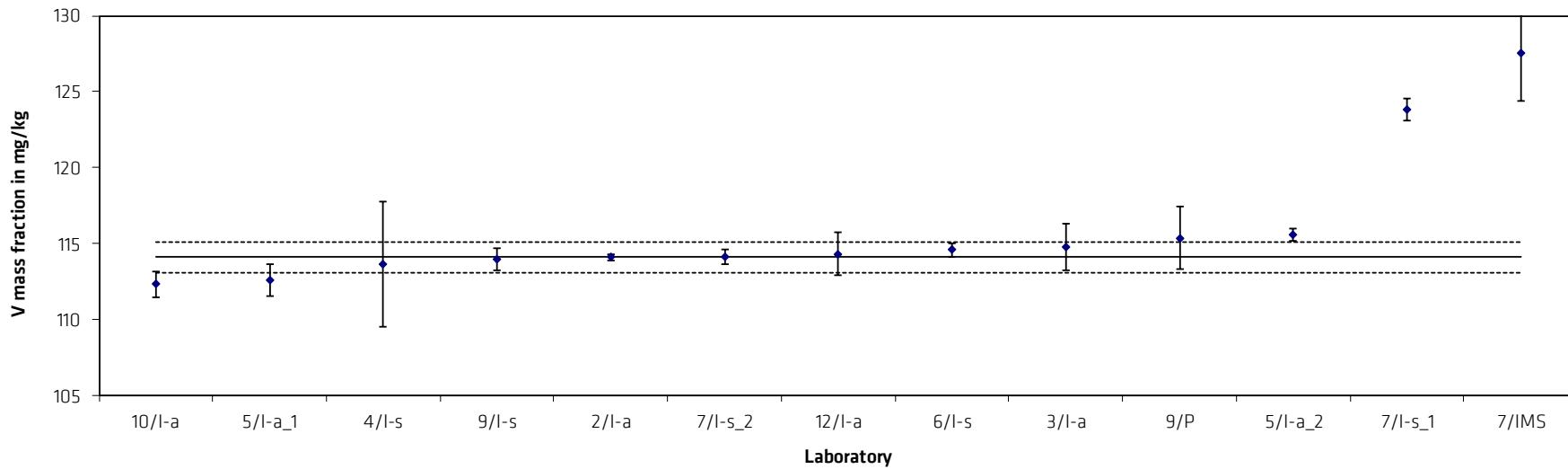
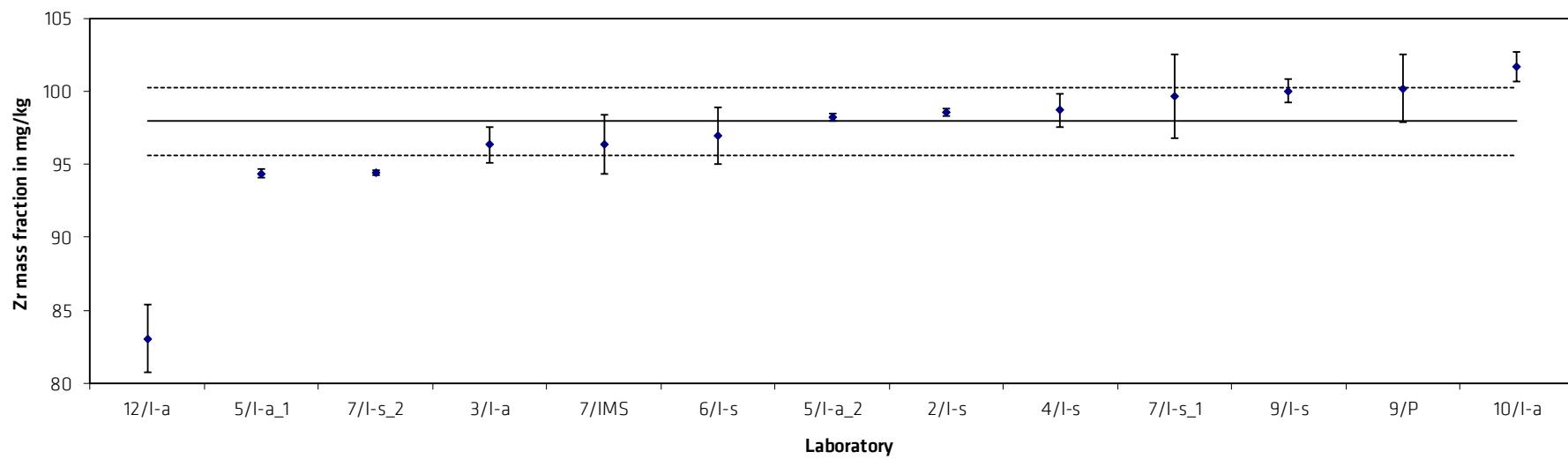


Table 23: Results for Zr

Lab./Meth.	12/I-a	5/I-a_1	7/I-s_2	3/I-a	7/IMS	6/I-s	5/I-a_2	2/I-s	4/I-s	7/I-s_1	9/I-s	9/P	10/I-a		
M_i [mg/kg]	85.4	93.9	94.6	95.0	96.1	98.4	98.5	98.4	99.5	103.0	99.5	104.5	101		n
	84.2	94.5	94.6	95.5	95.4	100.2	98.4	98.2	96.8	98.0	99.6	99.5	103		12
	83.7	94.6	94.2	95.5	93.2	96.5	98.1	98.7	99.5	100.0	100.0	100.7	101		
	83.5	94.4	94.4	96.5	97.5	95.5	98.4	98.9	99.4	95.0	99.3	102.3	101		
	78.7	94.6	94.4	97.5	99.2	95.9	98.2	98.9	99.2	100.0	100.2	99.5	101		
	82.8	94.2	94.4	98.0	96.7	95.4	97.9	98.4	97.8	102.0	101.5	99.5	103		
												98			
												97.1			
M [mg/kg]	83.1	94.4	94.4	96.3	96.4	97.0	98.2	98.6	98.7	99.7	100.0	100.2	101.7		98.0
s [mg/kg]	2.30	0.29	0.16	1.21	2.02	1.93	0.23	0.27	1.13	2.88	0.80	2.30	1.03	s_M [mg/kg]	2.31
s_{rel}	0.028	0.003	0.002	0.013	0.021	0.020	0.002	0.003	0.011	0.029	0.008	0.023	0.010	\bar{s}_i [mg/kg]	1.47
														s_{rel}	0.024



The data was statistically evaluated to detect outlying values (Grubbs, Nalimov, Dixon, Cochran). The Cochran-test was performed only once. The following results were obtained:

Tab. 24: Outcome of statistical tests on the results obtained for Si and Fe

	Si	Fe
Number of data sets	12	16
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	---	---
Dixon ($\alpha = 0.01$)	---	---
Nalimov ($\alpha = 0.05$)	Labs. 3 and 8	Lab. 7/I-s_2
Nalimov ($\alpha = 0.01$)	---	---
Grubbs ($\alpha = 0.05$)	---	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	Lab. 3	Lab. 7/I-s_1
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers were not removed.

Tab. 25: Outcome of statistical tests on the results obtained for Cu, Mn, and Mg

	Cu	Mn	Mg
Number of data sets	15	16	15
Scheffe's test (data compatible?)	yes	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	---	---	---
Dixon ($\alpha = 0.01$)	---	---	---
Nalimov ($\alpha = 0.05$)	Lab. 3	Lab. 3	Lab. 6
Nalimov ($\alpha = 0.01$)	---	Lab. 3	---
Grubbs ($\alpha = 0.05$)	---	---	---
Grubbs ($\alpha = 0.01$)	---	---	---
Grubbs Pair ($\alpha = 0.05$)	---	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---	---
Cochran ($\alpha = 0.01$)	Lab. 8/I-s	Lab. 4	Lab. 10
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal	Distribution: normal

The outliers were not removed.

Tab. 26: Outcome of statistical tests on the results obtained for Ni

	Ni	
Number of data sets	15	14
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	---	---
Dixon ($\alpha = 0.01$)	---	---
Nalimov ($\alpha = 0.05$)	Lab. 8/I-a	---
Nalimov ($\alpha = 0.01$)	Lab. 8/I-a	---
Grubbs ($\alpha = 0.05$)	---	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	Lab. 7/IMS	Lab. 7/IMS
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier (Lab. 8/I-a) was removed.

Tab. 27: Outcome of statistical tests on the results obtained for Cr

	1 st run	2 nd run
Number of data sets	16	15
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	Lab. 7/I-s_1	---
Dixon ($\alpha = 0.01$)	---	---
Nalimov ($\alpha = 0.05$)	Lab. 7/I-s_1	---
Nalimov ($\alpha = 0.01$)	Lab. 7/I-s_1	---
Grubbs ($\alpha = 0.05$)	Lab. 7/I-s_1	---
Grubbs ($\alpha = 0.01$)	Lab. 7/I-s_1	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	Lab. 7/IMS	Lab. 7/IMS
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier (Lab. 7/I-s_1, 1st run) was removed.

Tab. 28: Outcome of statistical tests on the results obtained for Zn and Ti

	Zn	Ti
Number of data sets	15	15
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	---	---
Dixon ($\alpha = 0.01$)	---	---
Nalimov ($\alpha = 0.05$)	Lab. 3	Lab. 8/I-a
Nalimov ($\alpha = 0.01$)	---	---
Grubbs ($\alpha = 0.05$)	---	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	Lab. 7/I-s_1	Lab. 7/I-s_1
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers were not removed.

Tab. 29: Outcome of statistical tests on the results obtained for B and Be

	B	Be
Number of data sets	6	11
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	---	---
Dixon ($\alpha = 0.01$)	---	---
Nalimov ($\alpha = 0.05$)	Lab. 4	Lab. 9/I-s
Nalimov ($\alpha = 0.01$)	---	---
Grubbs ($\alpha = 0.05$)	---	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	Lab. 6	Lab. 4
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers were not removed.

Tab. 30: Outcome of statistical tests on the results obtained for Bi

	1 st run	2 nd run
Number of data sets	12	11
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	Lab. 8/I-s	---
Dixon ($\alpha = 0.01$)	Lab. 8/I-s	---
Nalimov ($\alpha = 0.05$)	Lab. 8/I-s	Labs. 5/I-a_2 and 6
Nalimov ($\alpha = 0.01$)	Lab. 8/I-s	---
Grubbs ($\alpha = 0.05$)	Lab. 8/I-s	---
Grubbs ($\alpha = 0.01$)	Lab. 8/I-s	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier (Lab. 8/I-s, 1st run) was removed.

Tab. 31: Outcome of statistical tests on the results obtained for Ca and Ga

	Ca	Ga
Number of data sets	6	12
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	---	---
Dixon ($\alpha = 0.01$)	---	---
Nalimov ($\alpha = 0.05$)	---	Lab. 6
Nalimov ($\alpha = 0.01$)	---	---
Grubbs ($\alpha = 0.05$)	---	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	---	Labs. 6 and 3
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	---	Lab. 3
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers were not removed.

Tab. 32: Outcome of statistical tests on the results obtained for Cd

	1 st run	2 nd run
Number of data sets	13	11
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	Lab. 8/I-s	---
Dixon ($\alpha = 0.01$)	Lab. 8/I-s	---
Nalimov ($\alpha = 0.05$)	Lab. 8/I-s	---
Nalimov ($\alpha = 0.01$)	Lab. 8/I-s	---
Grubbs ($\alpha = 0.05$)	Lab. 8/I-s	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	Labs. 8/I-s and 5/I-a_1	---
Grubbs Pair ($\alpha = 0.01$)	Labs. 8/I-s and 5/I-a_1	---
Cochran ($\alpha = 0.01$)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers (Labs. 8/I-s and 5/I-a_1, 1st run) were removed.

Tab. 33: Outcome of statistical tests on the results obtained for Co and Li

	Co	Li
Number of data sets	12	12
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	---	---
Dixon ($\alpha = 0.01$)	---	---
Nalimov ($\alpha = 0.05$)	Lab. 5/I-a_1	---
Nalimov ($\alpha = 0.01$)	---	---
Grubbs ($\alpha = 0.05$)	---	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: not normal

The outlier was not removed.

Tab. 34: Outcome of statistical tests on the results obtained for Na and Sn

	Na	Sn
Number of data sets	8	13
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	---	---
Dixon ($\alpha = 0.01$)	---	---
Nalimov ($\alpha = 0.05$)	---	Lab. 7/IMS
Nalimov ($\alpha = 0.01$)	---	---
Grubbs ($\alpha = 0.05$)	---	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	---	Lab. 3
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers were not removed.

Tab. 35: Outcome of statistical tests on the results obtained for Pb

	1 st run	2 nd run
Number of data sets	11	10
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	---	---
Dixon ($\alpha = 0.01$)	---	---
Nalimov ($\alpha = 0.05$)	Lab. 5/I-a_2	---
Nalimov ($\alpha = 0.01$)	Lab. 5/I-a_2	---
Grubbs ($\alpha = 0.05$)	Lab. 5/I-a_2	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier (Lab. 5/I-a_2) was removed.

Tab. 36: Outcome of statistical tests on the results obtained for V

	1 st run	2 nd run
Number of data sets	13	11
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	Lab. 7/IMS	---
Dixon ($\alpha = 0.01$)	Lab. 7/IMS	---
Nalimov ($\alpha = 0.05$)	Lab. 7/IMS	---
Nalimov ($\alpha = 0.01$)	Lab. 7/IMS	---
Grubbs ($\alpha = 0.05$)	Lab. 7/IMS	---
Grubbs ($\alpha = 0.01$)	---	---
Grubbs Pair ($\alpha = 0.05$)	Labs. 7/IMS and 7/I-s_1	---
Grubbs Pair ($\alpha = 0.01$)	Labs. 7/IMS and 7/I-s_1	---
Cochran ($\alpha = 0.01$)	Lab. 4	Lab. 4
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers (Labs. 7/IMS and 7/I-s_1) were removed.

Tab. 37: Outcome of statistical tests on the results obtained for Zr

	1 st run	2 nd run
Number of data sets	13	12
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon ($\alpha = 0.05$)	Lab. 12	---
Dixon ($\alpha = 0.01$)	Lab. 12	---
Nalimov ($\alpha = 0.05$)	Lab. 12	---
Nalimov ($\alpha = 0.01$)	Lab. 12	---
Grubbs ($\alpha = 0.05$)	Lab. 12	---
Grubbs ($\alpha = 0.01$)	Lab. 12	---
Grubbs Pair ($\alpha = 0.05$)	---	---
Grubbs Pair ($\alpha = 0.01$)	---	---
Cochran ($\alpha = 0.01$)	Lab. 7/I-s_1	Lab. 7/I-s_1
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier (Lab. 12) was removed.

The certified mass fractions of all elements were calculated as mean of the accepted data sets. These values are given in Table 38.

The resp. combined uncertainties were calculated from the spread resulting from the certification inter-laboratory comparison (u_{ilc}) and the uncertainty contributions from possible inhomogeneity over the length ($u_{bb}(1)$) and over area ($u_{bb}(2)$) of the material using Equation 4.

$$u_{\text{combined}} = \sqrt{u_{ilc}^2 + u_{bb}(1)^2 + u_{bb}(2)^2} \quad (4)$$

with

$$u_{ilc} = \sqrt{\frac{s_m^2}{n}} : \text{uncertainty contribution resulting from inter-laboratory comparison}$$

n : number of data sets used for calculating the certified mass fraction of each element

Table 38: Uncertainty calculation ($u_{bb}(\text{rel})$) was calculated with the data from the homogeneity test (see Annex 1 and 2) and used for the calculation of $u_{bb}(1)$ and $u_{bb}(2)$)

	uncertainty contribution from				$u_{bb}(1)^{**}$	$u_{bb}(2)^{**}$	u_{combined}	U	$u_{bb}(\text{rel})$	
	M	n	s_m	u_{ilc}					Length	Area
	%	%	%	%						
Si	0.6958	12	0.01630	0.0047	0.0070	0.0055	0.0100	0.02008	1.0046	0.7846
Fe	0.4753	16	0.01417	0.0035	0.0042	0.0035	0.0065	0.01309	0.8932	0.7365
Cu	0.1999	15	0.00303	0.0008	0.0012	0.0025	0.0029	0.00575	0.6131	1.2401
Mn	1.3100	16	0.02985	0.0075	0.0019	0.0038	0.0086	0.01712	0.1413	0.2874
Mg	0.2260	15	0.00806	0.0021	0.0012	0.0005	0.0025	0.00492	0.5422	0.2077
Cr	0.1185	15	0.00186	0.0005	0.0011	0.0002	0.0012	0.00240	0.9047	0.2102
Ni	0.0293	14	0.00041	0.0001	0.0002	0.0001	0.0002	0.00043	0.5481	0.3147
Zn	0.1053	15	0.00143	0.0004	0.0004	0.0008	0.0010	0.00192	0.4115	0.7334
Ti	0.0279	15	0.00042	0.0001	0.0004	0.0003	0.0004	0.00090	1.2643	0.9139 *
	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		
B	3.59	6	0.941	0.3843	0.2646	0.3492	0.5828	1.1656	7.3700	9.7269 *
Be	7.19	11	0.193	0.0582	0.0286	0.0590	0.0877	0.1755	0.3983	0.8210 *
Bi	76.5	11	1.451	0.4375	0.7538	1.0954	1.3999	2.7998	0.9857	1.4323 *
Ca	19.9	6	0.793	0.3237	0.6847	0.3533	0.8357	1.6713	3.4345	1.7722
Cd	10.07	11	0.251	0.0758	0.0482	0.1092	0.1413	0.2827	0.4781	1.0836 *
Co	9.69	11	0.493	0.1488	0.0756	0.1034	0.1963	0.3926	0.7799	1.0669 *
Ga	57.7	12	4.755	1.3726	0.4523	0.2110	1.4605	2.9210	0.7835	0.3655
Li	18.10	12	1.094	0.3157		0.2037	0.3757	0.7514	segregation	1.1255
Na	16.80	6	1.224	0.4999		0.1727	0.5288	1.0577	segregation	1.0278
Pb	92.0	10	2.695	0.8521	0.7780	0.4219	1.2286	2.4572	0.8460	0.4587 *
Sn	97.7	13	2.643	0.7329	0.5582	0.7382	1.1806	2.36111	0.5715	0.7556 *
V	114.1	11	1.005	0.3030	1.0509	0.5959	1.2455	2.49104	0.9211	0.5222
Zr	98.0	12	2.308	0.6663	0.5103	0.4037	0.9313	1.86250	0.5209	0.4121
**calculated from $u_{bb}(\text{rel})$: $u_{bb} = \frac{M \cdot u_{bb}(\text{rel})}{100}$									*external laboratory	

The expanded uncertainties U are calculated by multiplication of u_{combined} with a coverage factor of $k = 2$ using Equation 5.

$$U = k \cdot u_{\text{combined}} \quad (5)$$

The calculated mass fractions and their resp. expanded uncertainties are given on Page 3 of this report. Rounding was done according to DIN 1333 [4].

In addition to the wet chemical characterisation an accompanying inter-laboratory comparison with spark emission was performed to check if there is agreement between SOES and wet chemistry. Tab. 39 shows the mean values of wet chemical and spark emission results as well as their standard deviations. The data obtained with wet chemistry and SOES are consistent for all elements considering their uncertainties. The data from the spark emission inter-laboratory comparison was not used for the calculation of the certified values.

Tab. 39: Comparison wet chemistry vs. SOES

Element	Wet chemical analysis			Spark emission		
	Mass fraction in %	Std.-dev. in %	n	Mass fraction in %	Std.-dev. in %	n
Si	0.696	0.017	12	0.692	0.027	11
Fe	0.475	0.015	16	0.489	0.010	10
Cu	0.200	0.004	15	0.201	0.006	10
Mn	1.310	0.030	16	1.298	0.028	9
Mg	0.226	0.009	15	0.232	0.011	10
Cr	0.119	0.002	15	0.122	0.005	11
Ni	0.0293	0.0005	14	0.0290	0.0012	10
Zn	0.1053	0.0015	15	0.1058	0.0033	10
Ti	0.0279	0.0005	15	0.0272	0.0010	11
	in mg/kg	in mg/kg		in mg/kg	in mg/kg	
B	3.6	1.0	6	5.5	2.4	8
Be	7.19	0.20	11	7.24	0.35	9
Bi	76.5	1.5	11	82.3	5.0	9
Ca	19.9	0.8	6	22.3	2.2	10
Cd	10.1	0.3	11	11.1	0.8	7
Co	9.7	0.5	11	9.1	1.8	8
Ga	57.7	4.8	12	54.2	8.9	10
Li	18.1	1.1	12	21.1	2.9	8
Na	15.7	2.4	8	19.2	2.2	9
Pb	92.0	2.7	10	81.3	14.2	9
Sn	97.7	2.7	13	97.2	3.5	9
V	114.1	1.0	11	115.0	8.2	11
Zr	98.0	2.4	12	95.0	8.4	10

6. Instructions for users and stability

The certified reference material BAM-M322 is intended for the calibration and quality control of spark emission and X-ray fluorescence spectrometers used for the analysis of similar materials. It is also suitable for validation and quality control of wet chemical analysis methods.

The surface of the material should be cleaned by turning or milling before analysis.

An area 8 mm in diameter in the centre of the discs should be avoided for spark optical emission spectrometry.

If chips prepared from the compact material are used for wet chemical analysis, a minimum sample intake of 0.2 g has to be used.

The material will remain stable provided that it is not subjected to excessive heat (eg, during preparation of the working surface).

7. Metrological Traceability

To ensure traceability of the certified mass fractions to the SI (Système International d'Unités) calibration was performed using standard solutions prepared from pure metals or stoichiometric compounds or traceable commercial calibration solutions.

8. Information on and purchase of the CRM

Certified reference material BAM-M322 is supplied by

Bundesanstalt für Materialforschung und -prüfung (BAM)

Division 1.6 „Inorganic Reference Materials“

Richard-Willstätter-Str. 11, D-12489 Berlin, Germany

Phone +49 (0)30 - 8104 2061

Fax: +49 (0)30 - 8104 72061

E-Mail: sales.crm@bam.de

Each disc of BAM-M322 will be distributed together with a detailed certificate containing the certified values and their uncertainties, the mean values and standard deviations of all accepted data sets and information on the analytical methods used and the names of the participating laboratories.

Information on certified reference materials can be obtained from BAM:

<https://www.bam.de>.

Tel. +49 30 8104 1111.

9. References

- [1] DIN EN ISO 17034, General requirements for the competence of reference material producers, 2016
- [2] ISO Guide 31, Reference materials - Contents of certificates, labels and accompanying documentation, 2015
- [3] ISO Guide 35, Reference materials - Guidance for characterization and assessment of homogeneity and stability, 2017
- [4] DIN 1333:1992-02 Zahlenangaben

Annex 1: Calculation of uncertainty contribution of potential inhomogeneity (length), SOES ($u_{bb}(rel.)$ here means u_{bb} (rel) Length in Table 38)

Silicon:

	1	2	3	4	5	
A1	0.693	0.686	0.691	0.688	0.695	
A2	0.677	0.678	0.68	0.675	0.679	
A3	0.671	0.672	0.671	0.677	0.679	
A4	0.673	0.674	0.669	0.668	0.671	
A5	0.677	0.676	0.675	0.672	0.675	
B1	0.674	0.671	0.673	0.671	0.673	
B2	0.669	0.668	0.674	0.67	0.672	
B3	0.674	0.68	0.669	0.67	0.684	
B4	0.673	0.677	0.669	0.671	0.676	
B5	0.687	0.688	0.682	0.68	0.688	
C1	0.669	0.67	0.674	0.672	0.67	
C2	0.671	0.672	0.672	0.673	0.673	
C3	0.678	0.684	0.681	0.684	0.683	
C4	0.671	0.679	0.676	0.677	0.676	
C5	0.673	0.673	0.674	0.671	0.675	
D1	0.687	0.682	0.686	0.677	0.688	
D2	0.671	0.671	0.67	0.674	0.673	
D3	0.668	0.665	0.667	0.669	0.676	
D4	0.669	0.671	0.669	0.671	0.673	
D5	0.676	0.672	0.673	0.677	0.678	
E1	0.669	0.669	0.668	0.669	0.673	
E2	0.669	0.671	0.67	0.667	0.671	
E3	0.68	0.682	0.686	0.682	0.683	
E4	0.671	0.671	0.673	0.664	0.669	
E5	0.689	0.684	0.686	0.681	0.688	
F1	0.674	0.669	0.672	0.676	0.676	
F2	0.684	0.684	0.685	0.696	0.685	
F3	0.669	0.67	0.666	0.668	0.672	
F4	0.669	0.666	0.669	0.667	0.67	
F5	0.672	0.671	0.669	0.668	0.674	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.0055976	29	0.000193	21.423068	6.86093E-35	1.562071
Within groups	0.0010812	120	9.01E-06			
Total	0.0066788	149				
within-sd	0.0030017					
effective n	4.00					
s_bb	0.0067825					
s_bb_min	0.0005393					
u_bb	0.0067825					
u_bb(rel.)	1.0045739					

Iron:

	1	2	3	4	5	
A1	0.503	0.498	0.504	0.500	0.509	
A2	0.491	0.493	0.496	0.489	0.491	
A3	0.483	0.488	0.486	0.495	0.496	
A4	0.489	0.489	0.484	0.484	0.485	
A5	0.491	0.491	0.487	0.489	0.490	
B1	0.490	0.487	0.492	0.491	0.492	
B2	0.488	0.488	0.493	0.490	0.493	
B3	0.491	0.497	0.487	0.487	0.500	
B4	0.487	0.489	0.484	0.485	0.488	
B5	0.495	0.493	0.493	0.490	0.495	
C1	0.490	0.493	0.495	0.496	0.494	
C2	0.489	0.490	0.490	0.491	0.493	
C3	0.486	0.494	0.491	0.493	0.493	
C4	0.487	0.496	0.493	0.494	0.495	
C5	0.486	0.488	0.490	0.489	0.489	
D1	0.500	0.496	0.500	0.494	0.503	
D2	0.488	0.487	0.484	0.492	0.490	
D3	0.491	0.487	0.491	0.491	0.498	
D4	0.483	0.489	0.485	0.490	0.492	
D5	0.489	0.485	0.488	0.490	0.492	
E1	0.488	0.488	0.489	0.489	0.492	
E2	0.486	0.484	0.487	0.484	0.488	
E3	0.497	0.496	0.501	0.496	0.498	
E4	0.485	0.487	0.489	0.482	0.486	
E5	0.496	0.492	0.493	0.488	0.495	
F1	0.486	0.485	0.486	0.491	0.490	
F2	0.497	0.497	0.499	0.508	0.499	
F3	0.486	0.491	0.485	0.489	0.491	
F4	0.490	0.489	0.490	0.489	0.491	
F5	0.491	0.490	0.488	0.489	0.490	
<i>Source of variation</i>	<i>sums of squares (SS)</i>	<i>degrees of freedom (df)</i>	<i>Mean squares (MS)</i>	<i>F-value</i>	<i>P-value</i>	<i>critical F-value</i>
Between groups	0.0024985	29	8.61538E-05	9.3645427	2.40709E-19	1.562071
Within groups	0.001104	120	9.2E-06			
Total	0.0036025	149				
within-sd	0.0030332					
effective n	4.00					
s_bb	0.0043862					
s_bb_min	0.0005449					
u_bb	0.0043862					
u_bb(rel.)	0.8932036					

Copper:

	1	2	3	4	5	
A1	0.206	0.204	0.204	0.202	0.206	
A2	0.200	0.198	0.201	0.200	0.202	
A3	0.198	0.197	0.197	0.202	0.202	
A4	0.200	0.199	0.198	0.198	0.200	
A5	0.200	0.198	0.198	0.199	0.199	
B1	0.200	0.201	0.202	0.202	0.203	
B2	0.199	0.198	0.202	0.201	0.201	
B3	0.202	0.205	0.199	0.202	0.207	
B4	0.198	0.202	0.198	0.198	0.203	
B5	0.199	0.201	0.199	0.200	0.204	
C1	0.200	0.199	0.200	0.199	0.201	
C2	0.199	0.201	0.199	0.202	0.204	
C3	0.198	0.201	0.199	0.203	0.201	
C4	0.196	0.200	0.202	0.202	0.201	
C5	0.199	0.199	0.201	0.202	0.203	
D1	0.201	0.198	0.201	0.197	0.202	
D2	0.197	0.196	0.197	0.199	0.201	
D3	0.198	0.198	0.197	0.201	0.203	
D4	0.198	0.200	0.199	0.202	0.204	
D5	0.197	0.197	0.200	0.198	0.202	
E1	0.199	0.199	0.197	0.199	0.200	
E2	0.200	0.198	0.201	0.199	0.203	
E3	0.200	0.200	0.203	0.203	0.202	
E4	0.197	0.198	0.199	0.196	0.198	
E5	0.201	0.199	0.201	0.198	0.203	
F1	0.200	0.197	0.199	0.202	0.200	
F2	0.199	0.201	0.201	0.205	0.203	
F3	0.200	0.199	0.198	0.202	0.202	
F4	0.200	0.197	0.198	0.198	0.203	
F5	0.199	0.198	0.199	0.197	0.202	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.0002853	29	9.83908E-06	2.577925	0.0001771	1.562071
Within groups	0.000458	120	3.81667E-06			
Total	0.0007433	149				
within-sd	0.0019536					
effective n	4.00					
s_bb	0.001227					
s_bb_min	0.000351					
u_bb	0.001227					
u_bb(rel.)	0.6131064					

Manganese:

	1	2	3	4	5	
A1	1.325	1.320	1.323	1.321	1.320	
A2	1.325	1.321	1.321	1.322	1.327	
A3	1.324	1.320	1.328	1.322	1.324	
A4	1.319	1.333	1.320	1.330	1.327	
A5	1.324	1.323	1.329	1.330	1.328	
B1	1.329	1.324	1.324	1.329	1.330	
B2	1.325	1.323	1.326	1.329	1.326	
B3	1.326	1.325	1.326	1.324	1.322	
B4	1.327	1.333	1.328	1.325	1.328	
B5	1.321	1.325	1.324	1.326	1.323	
C1	1.328	1.320	1.331	1.324	1.315	
C2	1.323	1.328	1.324	1.328	1.326	
C3	1.318	1.325	1.318	1.329	1.322	
C4	1.321	1.326	1.327	1.326	1.318	
C5	1.327	1.333	1.323	1.329	1.329	
D1	1.321	1.323	1.326	1.315	1.329	
D2	1.323	1.327	1.328	1.323	1.324	
D3	1.321	1.317	1.312	1.325	1.325	
D4	1.321	1.321	1.323	1.329	1.326	
D5	1.325	1.329	1.324	1.331	1.332	
E1	1.323	1.327	1.321	1.322	1.328	
E2	1.327	1.330	1.333	1.329	1.327	
E3	1.316	1.320	1.326	1.320	1.321	
E4	1.328	1.325	1.326	1.325	1.324	
E5	1.321	1.326	1.323	1.322	1.328	
F1	1.328	1.327	1.324	1.332	1.326	
F2	1.326	1.321	1.323	1.318	1.323	
F3	1.331	1.321	1.324	1.326	1.330	
F4	1.319	1.317	1.327	1.318	1.331	
F5	1.327	1.325	1.323	1.324	1.331	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.0007984	29	2.75301E-05	2.0367533	0.0040463	1.562071
Within groups	0.001622	120	1.35167E-05			
Total	0.0024204	149				
within-sd	0.0036765					
effective n	4.00					
s_bb	0.0018717					
s_bb_min	0.0006605					
u_bb	0.0018717					
u_bb(rel.)	0.1412894					

Magnesium:

	1	2	3	4	5	
A1	0.241	0.239	0.241	0.239	0.242	
A2	0.236	0.236	0.239	0.237	0.239	
A3	0.235	0.234	0.234	0.239	0.237	
A4	0.235	0.235	0.235	0.235	0.235	
A5	0.235	0.234	0.235	0.235	0.236	
B1	0.238	0.238	0.239	0.239	0.240	
B2	0.236	0.235	0.238	0.237	0.238	
B3	0.236	0.239	0.237	0.237	0.240	
B4	0.234	0.238	0.235	0.235	0.237	
B5	0.236	0.235	0.235	0.235	0.237	
C1	0.237	0.237	0.238	0.238	0.238	
C2	0.236	0.237	0.237	0.238	0.238	
C3	0.234	0.237	0.235	0.238	0.236	
C4	0.233	0.236	0.236	0.236	0.237	
C5	0.234	0.235	0.236	0.236	0.238	
D1	0.237	0.236	0.238	0.235	0.239	
D2	0.234	0.236	0.234	0.237	0.237	
D3	0.235	0.234	0.234	0.237	0.238	
D4	0.234	0.236	0.235	0.238	0.239	
D5	0.234	0.234	0.234	0.235	0.237	
E1	0.236	0.236	0.237	0.237	0.238	
E2	0.237	0.235	0.239	0.235	0.239	
E3	0.236	0.237	0.240	0.237	0.238	
E4	0.235	0.235	0.236	0.234	0.236	
E5	0.235	0.234	0.234	0.233	0.237	
F1	0.237	0.236	0.237	0.239	0.238	
F2	0.235	0.237	0.238	0.240	0.239	
F3	0.236	0.237	0.235	0.237	0.238	
F4	0.234	0.234	0.236	0.235	0.237	
F5	0.235	0.234	0.236	0.235	0.237	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.000248	29	8.5508E-06	4.325870791	6.59448E-09	1.562071
Within groups	0.0002372	120	1.97667E-06			
Total	0.0004852	149				
within-sd	0.0014059					
effective n	4.00					
s_bb	0.001282					
s_bb_min	0.0002526					
u_bb	0.001282					
u_bb(rel.)	0.5421806					

Chromium:

	1	2	3	4	5
A1	0.123	0.121	0.122	0.121	0.124
A2	0.120	0.120	0.121	0.119	0.120
A3	0.118	0.119	0.118	0.120	0.120
A4	0.119	0.119	0.118	0.118	0.118
A5	0.120	0.120	0.119	0.120	0.120
B1	0.119	0.119	0.120	0.120	0.120
B2	0.118	0.118	0.119	0.119	0.119
B3	0.119	0.121	0.119	0.119	0.121
B4	0.118	0.120	0.119	0.119	0.119
B5	0.120	0.120	0.120	0.120	0.121
C1	0.118	0.118	0.119	0.119	0.119
C2	0.118	0.119	0.119	0.118	0.119
C3	0.118	0.121	0.120	0.120	0.121
C4	0.117	0.120	0.120	0.120	0.120
C5	0.118	0.118	0.120	0.119	0.119
D1	0.121	0.120	0.121	0.119	0.122
D2	0.118	0.118	0.117	0.120	0.119
D3	0.118	0.118	0.118	0.118	0.120
D4	0.117	0.119	0.118	0.120	0.120
D5	0.119	0.118	0.119	0.120	0.120
E1	0.117	0.118	0.118	0.118	0.119
E2	0.119	0.118	0.119	0.118	0.119
E3	0.120	0.121	0.122	0.121	0.121
E4	0.118	0.118	0.119	0.117	0.118
E5	0.120	0.119	0.120	0.118	0.121
F1	0.119	0.118	0.119	0.120	0.120
F2	0.120	0.121	0.121	0.123	0.122
F3	0.118	0.119	0.118	0.119	0.120
F4	0.118	0.118	0.118	0.118	0.119
F5	0.119	0.118	0.118	0.117	0.118

Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.0001574	29	5.42736E-06	7.0485147	5.46526E-15	1.562071
Within groups	9.24E-05	120	7.7E-07			
Total	0.0002498	149				
within-sd	0.0008775					
effective n	4.00					
s_bb	0.001079					
s_bb_min	0.0001576					
u_bb	0.001079					
u_bb(rel.)	0.9046829					

Nickel:

	1	2	3	4	5	
A1	0.030	0.029	0.029	0.029	0.029	
A2	0.029	0.029	0.029	0.030	0.029	
A3	0.029	0.029	0.029	0.029	0.030	
A4	0.029	0.029	0.029	0.029	0.029	
A5	0.029	0.029	0.029	0.029	0.029	
B1	0.029	0.029	0.029	0.029	0.030	
B2	0.029	0.029	0.030	0.030	0.030	
B3	0.029	0.030	0.029	0.030	0.030	
B4	0.029	0.029	0.029	0.029	0.029	
B5	0.029	0.028	0.029	0.029	0.029	
C1	0.029	0.030	0.030	0.029	0.030	
C2	0.029	0.029	0.029	0.030	0.030	
C3	0.029	0.029	0.028	0.029	0.029	
C4	0.029	0.029	0.030	0.030	0.030	
C5	0.029	0.029	0.029	0.030	0.030	
D1	0.029	0.029	0.029	0.029	0.030	
D2	0.029	0.029	0.029	0.029	0.030	
D3	0.029	0.029	0.029	0.030	0.029	
D4	0.029	0.029	0.029	0.029	0.029	
D5	0.029	0.029	0.029	0.029	0.030	
E1	0.029	0.029	0.029	0.029	0.030	
E2	0.029	0.029	0.029	0.029	0.029	
E3	0.029	0.030	0.029	0.030	0.030	
E4	0.029	0.029	0.029	0.029	0.029	
E5	0.029	0.029	0.029	0.029	0.029	
F1	0.029	0.029	0.029	0.030	0.030	
F2	0.029	0.029	0.029	0.030	0.030	
F3	0.029	0.029	0.029	0.030	0.030	
F4	0.029	0.029	0.029	0.030	0.030	
F5	0.029	0.029	0.029	0.029	0.029	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	8.29333E-06	29	2.85977E-07	1.559874608	0.0505393	1.562071
Within groups	2.2E-05	120	1.83333E-07			
Total	3.02933E-05	149				
within-sd	0.000428174					
effective n	4.00					
s_bb	0.00016019					
s_bb_min	7.69224E-05					
u_bb	0.00016019					
u_bb(rel.)	0.548096238					

Zinc:

	1	2	3	4	5	
A1	0.103	0.103	0.102	0.102	0.103	
A2	0.102	0.100	0.102	0.101	0.102	
A3	0.101	0.099	0.100	0.102	0.101	
A4	0.101	0.101	0.100	0.101	0.101	
A5	0.101	0.100	0.101	0.101	0.101	
B1	0.101	0.101	0.102	0.102	0.102	
B2	0.101	0.100	0.102	0.101	0.102	
B3	0.102	0.103	0.101	0.102	0.103	
B4	0.100	0.102	0.100	0.100	0.102	
B5	0.101	0.101	0.100	0.101	0.102	
C1	0.101	0.101	0.102	0.101	0.102	
C2	0.101	0.102	0.101	0.102	0.103	
C3	0.100	0.101	0.100	0.102	0.101	
C4	0.099	0.101	0.102	0.102	0.102	
C5	0.101	0.101	0.101	0.102	0.102	
D1	0.101	0.101	0.101	0.099	0.102	
D2	0.100	0.100	0.100	0.101	0.101	
D3	0.101	0.100	0.100	0.102	0.103	
D4	0.100	0.101	0.101	0.102	0.103	
D5	0.100	0.100	0.100	0.101	0.102	
E1	0.101	0.101	0.100	0.101	0.101	
E2	0.101	0.101	0.102	0.101	0.103	
E3	0.101	0.102	0.103	0.102	0.102	
E4	0.101	0.101	0.101	0.100	0.101	
E5	0.102	0.100	0.101	0.101	0.102	
F1	0.101	0.100	0.101	0.102	0.102	
F2	0.100	0.101	0.102	0.103	0.102	
F3	0.101	0.101	0.101	0.102	0.102	
F4	0.100	0.099	0.100	0.100	0.102	
F5	0.101	0.101	0.101	0.100	0.102	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	4.09933E-05	29	1.41356E-06	1.9632822	0.0060915	1.562071
Within groups	8.64E-05	120	7.2E-07			
Total	0.000127393	149				
within-sd	0.000848528					
effective n	4.00					
s_bb	0.000416402					
s_bb_min	0.00015244					
u_bb	0.000416402					
u_bb(rel.)	0.411491747					

Titanium:

	1	2	3	4	5
A1	0.028	0.028	0.028	0.028	0.028
A2	0.027	0.028	0.027	0.027	0.028
A3	0.027	0.027	0.027	0.028	0.028
A4	0.027	0.028	0.027	0.028	0.027
A5	0.027	0.027	0.027	0.027	0.028
B1	0.028	0.028	0.028	0.028	0.028
B2	0.027	0.028	0.028	0.028	0.028
B3	0.027	0.028	0.028	0.028	0.028
B4	0.027	0.027	0.027	0.027	0.027
B5	0.027	0.027	0.027	0.027	0.027
C1	0.028	0.028	0.028	0.028	0.028
C2	0.028	0.028	0.028	0.027	0.028
C3	0.027	0.027	0.027	0.027	0.027
C4	0.027	0.028	0.028	0.028	0.028
C5	0.027	0.027	0.027	0.027	0.027
D1	0.028	0.028	0.028	0.027	0.028
D2	0.027	0.028	0.028	0.028	0.027
D3	0.028	0.028	0.028	0.028	0.028
D4	0.027	0.027	0.027	0.027	0.027
D5	0.027	0.027	0.027	0.027	0.028
E1	0.028	0.028	0.027	0.028	0.028
E2	0.027	0.027	0.028	0.027	0.027
E3	0.027	0.028	0.028	0.028	0.028
E4	0.028	0.027	0.027	0.028	0.028
E5	0.027	0.027	0.027	0.027	0.027
F1	0.027	0.027	0.027	0.028	0.028
F2	0.028	0.028	0.028	0.028	0.028
F3	0.028	0.027	0.027	0.028	0.028
F4	0.028	0.027	0.028	0.027	0.028
F5	0.028	0.028	0.027	0.027	0.028
	degrees of freedom				
Source of variation	sums of squares (SS)	(df)	Mean squares (MS)	F-value	critical F-value
Between groups	1.85933E-05	29	6.41149E-07	4.09244314	2.47173E-08
Within groups	0.0000188	120	1.56667E-07		
Total	3.73933E-05	149			

within-sd	0.000395811
effective n	4.00
s_bb	0.000348024
s_bb_min	7.11083E-05
u_bb	0.000348024
u_bb(rel.)	1.264315737

Boron:

	1	2	3	4	5	
A1	4.9	4.2	4.7	4.2	6.0	
A2	3.7	4.6	4.0	4.0	4.0	
A3	3.8	5.8	5.1	4.5	3.9	
A4	5.2	4.6	4.3	4.5	4.4	
A5	4.4	4.2	3.9	4.2	4.5	
B1	4.6	5.8	5.7	5.3	5.4	
B2	3.9	4.4	4.1	3.7	4.4	
B3	3.8	5.1	4.4	4.2	4.2	
B4	4.4	4.6	3.8	4.9	3.7	
B5	3.9	4.2	4.0	4.2	3.4	
C1	5.2	4.0	4.9	3.9	4.0	
C2	3.9	4.1	5.5	4.6	4.9	
C3	3.9	4.7	3.9	4.2	4.2	
C4	4.3	3.7	4.4	4.3	4.7	
C5	3.7	4.1	4.0	3.6	3.5	
D1	4.5	4.3	5.7	4.4	4.3	
D2	4.9	4.3	4.7	5.4	3.9	
D3	3.9	3.6	4.7	3.4	6.0	
D4	4.1	4.3	3.7	3.8	4.0	
D5	3.9	3.6	4.3	3.5	3.5	
E1	4.8	3.7	4.4	4.7	4.4	
E2	3.9	4.1	4.9	4.1	4.0	
E3	4.5	4.8	3.9	4.1	4.1	
E4	3.8	3.8	3.5	4.9	4.2	
E5	3.7	4.5	3.7	3.7	3.9	
F1	4.3	4.9	4.3	4.9	6.0	
F2	3.7	3.6	4.3	4.3	4.2	
F3	4.1	3.7	4.4	5.6	4.7	
F4	3.6	4.0	4.3	3.8	3.5	
F5	3.6	4.4	3.7	4.0	4.2	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	19.131733	29	0.6597149	2.5547242	0.0002031	1.562071
Within groups	30.988	120	0.2582333			
Total	50.119733	149				
within-sd	0.5081666					
effective n	4.00					
s_bb	0.3168129					
s_bb_min	0.0912932					
u_bb	0.3168129					
u_bb(rel.)	7.3700267					

Beryllium:

	1	2	3	4	5	
A1	7.4	7.5	7.5	7.5	7.5	
A2	7.5	7.5	7.5	7.5	7.5	
A3	7.4	7.5	7.5	7.4	7.5	
A4	7.4	7.5	7.5	7.5	7.4	
A5	7.4	7.5	7.4	7.4	7.4	
B1	7.5	7.5	7.5	7.5	7.5	
B2	7.5	7.4	7.5	7.5	7.5	
B3	7.5	7.4	7.5	7.5	7.4	
B4	7.4	7.4	7.4	7.4	7.4	
B5	7.4	7.4	7.5	7.4	7.4	
C1	7.5	7.5	7.5	7.5	7.5	
C2	7.5	7.5	7.5	7.5	7.5	
C3	7.5	7.5	7.4	7.5	7.4	
C4	7.5	7.5	7.4	7.5	7.4	
C5	7.4	7.5	7.4	7.4	7.4	
D1	7.6	7.5	7.5	7.5	7.5	
D2	7.5	7.5	7.5	7.5	7.5	
D3	7.5	7.5	7.5	7.5	7.5	
D4	7.5	7.4	7.4	7.5	7.4	
D5	7.4	7.5	7.5	7.4	7.4	
E1	7.5	7.5	7.5	7.5	7.5	
E2	7.5	7.5	7.5	7.5	7.5	
E3	7.5	7.5	7.5	7.5	7.4	
E4	7.4	7.5	7.4	7.5	7.4	
E5	7.4	7.4	7.4	7.4	7.4	
F1	7.5	7.5	7.5	7.5	7.4	
F2	7.5	7.4	7.5	7.3	7.5	
F3	7.5	7.5	7.5	7.4	7.4	
F4	7.4	7.5	7.5	7.5	7.4	
F5	7.5	7.4	7.4	7.5	7.4	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.1576	29	0.0054345	2.8602541	3.33142E-05	1.562071
Within groups	0.228	120	0.0019			
Total	0.3856	149				
within-sd	0.043589					
effective n	4.00					
s_bb	0.0297258					
s_bb_min	0.0078309					
u_bb	0.0297258					
u_bb(rel.)	0.3982551					

Bismuth:

	1	2	3	4	5	
A1	71	70	70	70	70	
A2	70	69	69	70	70	
A3	69	69	69	70	71	
A4	70	68	70	69	70	
A5	68	67	69	68	70	
B1	68	69	70	70	71	
B2	69	69	71	71	71	
B3	68	71	69	71	72	
B4	69	68	69	68	68	
B5	67	67	68	67	69	
C1	70	70	71	70	72	
C2	69	69	68	70	71	
C3	68	68	67	69	69	
C4	69	69	71	69	71	
C5	68	68	69	71	70	
D1	68	69	69	68	70	
D2	69	70	68	69	71	
D3	68	69	69	71	70	
D4	68	69	69	70	70	
D5	67	68	70	69	70	
E1	68	69	70	69	71	
E2	69	69	69	70	70	
E3	68	70	69	70	71	
E4	68	68	69	69	69	
E5	67	68	68	67	68	
F1	70	70	71	71	71	
F2	69	70	69	70	70	
F3	69	68	69	71	70	
F4	69	68	69	70	70	
F5	69	70	68	69	70	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	81.073333	29	2.7956322	3.0060561	1.40301E-05	1.562071
Within groups	111.6	120	0.93			
Total	192.67333	149				
within-sd	0.9643651					
effective n	4.00					
s_bb	0.6829407					
s_bb_min	0.1732502					
u_bb	0.6829407					
u_bb(rel.)	0.9856741					

Calcium:

	1	2	3	4	5	
A1	23	23	23	23	23	
A2	22	23	23	23	24	
A3	22	22	22	22	22	
A4	22	21	22	22	21	
A5	21	21	22	21	22	
B1	23	23	23	23	23	
B2	22	22	22	23	22	
B3	21	22	22	22	22	
B4	21	21	21	21	22	
B5	21	21	21	21	21	
C1	23	23	23	23	23	
C2	22	22	22	22	22	
C3	22	21	21	23	23	
C4	22	22	22	21	22	
C5	21	21	21	21	21	
D1	23	23	24	23	23	
D2	22	22	22	22	23	
D3	22	22	22	22	22	
D4	21	22	21	22	22	
D5	21	22	22	21	22	
E1	23	23	23	23	23	
E2	22	22	22	22	22	
E3	22	22	22	22	22	
E4	21	21	22	21	21	
E5	21	21	21	21	21	
F1	24	23	23	23	23	
F2	22	23	22	22	22	
F3	22	21	22	22	22	
F4	21	21	21	22	22	
F5	21	21	21	22	21	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	71.173333	29	2.4542529	14.159151	1.23125E-26	1.562071
Within groups	20.8	120	0.1733333			
Total	91.973333	149				
within-sd	0.4163332					
effective n	4.00					
s_bb	0.7551357					
s_bb_min	0.0747951					
u_bb	0.7551357					
u_bb(rel.)	3.4345164					

Cadmium:

	1	2	3	4	5	
A1	9.9	10.3	9.6	9.6	10.1	
A2	10.2	9.8	10.2	9.7	10.2	
A3	9.9	9.9	10.4	10.3	9.7	
A4	9.6	9.6	9.6	10.3	10.3	
A5	10.1	9.6	9.8	10.4	10.3	
B1	9.9	10.0	9.9	9.6	9.8	
B2	9.8	9.8	10.4	9.9	9.6	
B3	9.6	10.4	10.2	9.7	10.4	
B4	10.0	9.7	9.9	9.6	10.2	
B5	9.9	10.4	10.4	9.9	10.0	
C1	10.0	9.9	9.7	10.1	10.0	
C2	9.7	10.4	9.8	9.9	10.2	
C3	10.4	10.4	10.2	10.0	10.1	
C4	9.7	10.1	10.4	9.6	10.3	
C5	10.2	9.8	10.1	9.7	9.7	
D1	10.1	9.6	10.1	9.9	10.1	
D2	9.8	10.2	10.3	9.7	10.4	
D3	10.0	10.4	10.0	9.6	10.0	
D4	10.2	10.0	9.9	9.6	10.1	
D5	9.7	10.0	10.0	10.0	9.7	
E1	10.3	9.9	10.3	9.6	9.8	
E2	10.2	9.7	10.0	9.8	9.7	
E3	10.0	10.1	10.1	10.1	9.7	
E4	10.0	10.2	10.0	9.9	9.7	
E5	9.8	10.4	10.2	10.1	10.4	
F1	10.0	10.0	10.0	10.1	9.8	
F2	10.1	9.9	9.9	10.3	10.1	
F3	9.7	9.6	10.3	9.8	10.3	
F4	10.3	9.6	10.0	10.3	10.0	
F5	10.0	9.9	9.7	9.6	10.4	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	1.2046	29	0.0415379	0.5880783	0.9504309	1.562071
Within groups	8.476	120	0.0706333			
Total	9.6806	149				
within-sd	0.2657693					
effective n	4.00					
s_bb	0					
s_bb_min	0.047746					
u_bb	0.047746					
u_bb(rel.)	0.4781294					

Cobalt:

	1	2	3	4	5	
A1	9.9	9.7	9.7	9.8	9.9	
A2	9.7	9.6	9.7	9.8	9.8	
A3	9.7	9.8	9.7	9.8	10	
A4	9.9	9.6	9.8	9.7	9.7	
A5	9.7	9.4	9.7	9.6	9.7	
B1	9.6	9.7	9.8	9.7	9.9	
B2	9.7	9.7	9.9	10	9.9	
B3	9.8	10	9.7	9.8	10.1	
B4	9.6	9.5	9.5	9.4	9.6	
B5	9.6	9.4	9.6	9.5	9.7	
C1	9.7	9.7	10	9.7	9.9	
C2	9.7	9.6	9.5	9.9	9.9	
C3	9.5	9.6	9.5	9.7	9.7	
C4	9.7	9.8	9.8	9.8	10	
C5	9.5	9.6	9.6	9.8	9.7	
D1	9.7	9.8	9.7	9.6	9.9	
D2	9.7	9.8	9.5	9.7	9.9	
D3	9.7	9.6	9.8	9.9	9.8	
D4	9.7	9.7	9.6	9.8	9.8	
D5	9.5	9.6	9.8	9.7	9.8	
E1	9.6	9.7	9.8	9.5	10	
E2	9.6	9.7	9.7	9.6	9.9	
E3	9.6	9.9	9.7	9.8	9.9	
E4	9.6	9.6	9.7	9.5	9.6	
E5	9.5	9.6	9.6	9.6	9.6	
F1	9.6	9.7	9.9	9.8	9.9	
F2	9.6	9.8	9.6	9.8	9.9	
F3	9.7	9.5	9.7	9.8	9.8	
F4	9.8	9.7	9.7	9.8	9.9	
F5	9.7	9.7	9.6	9.7	9.7	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	1.0856	29	0.0374345	2.5876371	0.0001673	1.562071
Within groups	1.736	120	0.0144667			
Total	2.8216	149				
within-sd	0.1202775					
effective n	4.00					
s_bb	0.0757757					
s_bb_min	0.0216081					
u_bb	0.0757757					
u_bb(rel.)	0.7799062					

Gallium:

	1	2	3	4	5	
A1	69	68	68	68	69	
A2	68	68	68	69	69	
A3	68	68	67	69	69	
A4	68	66	69	69	68	
A5	66	66	68	67	69	
B1	67	67	69	68	69	
B2	67	68	69	69	69	
B3	67	69	68	69	72	
B4	68	66	67	66	68	
B5	66	66	67	66	68	
C1	67	68	69	68	69	
C2	67	67	67	69	69	
C3	66	66	66	67	67	
C4	67	68	69	68	69	
C5	67	67	68	69	69	
D1	67	67	67	66	69	
D2	67	68	67	67	69	
D3	66	68	68	69	68	
D4	68	68	68	69	69	
D5	66	67	68	68	69	
E1	66	66	67	67	69	
E2	67	67	68	67	69	
E3	67	69	68	69	69	
E4	67	66	68	68	68	
E5	66	66	67	67	66	
F1	68	67	69	69	69	
F2	67	69	67	69	69	
F3	68	67	68	69	69	
F4	67	66	68	69	68	
F5	67	68	67	68	69	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	60.94	29	2.1013793	2.1589513	0.0020269	1.562071
Within groups	116.8	120	0.9733333			
Total	177.74	149				
within-sd	0.9865766					
effective n	4.00					
s_bb	0.5310475					
s_bb_min	0.1772405					
u_bb	0.5310475					
u_bb(rel.)	0.7834871					

Lithium:

	1	2	3	4	5	
A1	19	19	19	19	19	19
A2	18	18	18	18	18	18
A3	17	16	17	17	17	16.8
A4	16	16	16	16	16	16
A5	16	16	16	15	16	15.8
B1	19	19	19	19	19	19
B2	18	18	18	18	18	18
B3	16	17	17	17	17	16.8
B4	16	16	16	16	16	16
B5	16	15	16	16	16	15.8
C1	19	19	19	19	19	19
C2	17	17	18	17	17	17.2
C3	17	17	16	17	16	16.6
C4	16	16	16	15	17	16
C5	16	15	15	16	16	15.6
D1	19	19	19	19	19	19
D2	18	18	18	18	18	18
D3	17	17	17	17	17	17
D4	16	16	16	17	16	16.2
D5	15	15	16	15	16	15.4
E1	19	19	19	19	19	19
E2	18	17	18	18	18	17.8
E3	17	17	17	17	17	17
E4	16	16	16	16	16	16
E5	16	15	16	16	16	15.8
F1	19	19	19	19	19	19
F2	18	18	18	18	18	18
F3	17	17	17	17	17	17
F4	16	16	16	16	16	16
F5	15	15	16	16	16	15.6

Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	225.84	29	7.78758621	70.7962382	3.1577E-62	1.56207098
Within groups	13.2	120	0.11			
Total	239.04	149				

within-sd	0.331662
effective n	4.00
s_bb	1.385423
s_bb_min	0.059584
u_bb	1.385423
u_bb(rel.)	8.11137517

Sodium:

	1	2	3	4	5	
A1	19	19	19	19	20	19.2
A2	18	18	18	18	19	18.2
A3	16	16	17	17	17	16.6
A4	16	16	16	16	15	15.8
A5	15	15	15	15	15	15
B1	19	19	19	19	19	19
B2	18	18	18	18	18	18
B3	16	17	17	17	17	16.8
B4	16	16	15	16	16	15.8
B5	15	15	15	15	15	15
C1	19	19	19	19	20	19.2
C2	17	17	18	17	17	17.2
C3	17	17	16	17	16	16.6
C4	15	16	16	15	16	15.6
C5	15	15	15	15	15	15
D1	19	19	19	19	19	19
D2	18	18	18	18	18	18
D3	17	17	17	17	17	17
D4	16	16	16	17	16	16.2
D5	15	15	15	14	15	14.8
E1	19	19	19	19	19	19
E2	18	17	18	18	18	17.8
E3	16	17	17	17	17	16.8
E4	15	16	16	16	16	15.8
E5	15	15	15	15	15	15
F1	19	19	19	19	19	19
F2	17	18	18	18	18	17.8
F3	17	17	17	17	17	17
F4	16	16	16	16	16	16
F5	15	15	15	15	15	15
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	316.693333	29	10.9204598	93.6039409	4.5016E-69	1.56207098
Within groups		14	0.11666667			
Total	330.693333	149				
within-sd	0.341565					
effective n	4.00					
s_bb	1.643456					
s_bb_min	0.061363					
u_bb	1.643456					
u_bb (rel.)	9.72075827					

Lead:

	1	2	3	4	5	
A1	91	87	87	90	88	
A2	88	87	88	90	88	
A3	88	88	87	88	90	
A4	88	86	90	88	88	
A5	86	86	88	87	90	
B1	86	86	90	87	90	
B2	87	88	90	91	90	
B3	87	91	88	91	93	
B4	87	86	87	86	87	
B5	85	85	86	86	88	
C1	88	88	90	88	91	
C2	86	87	87	91	90	
C3	86	86	85	87	87	
C4	87	87	90	88	90	
C5	87	87	87	90	88	
D1	86	86	87	86	88	
D2	87	88	87	87	90	
D3	87	88	88	90	88	
D4	88	88	88	90	90	
D5	85	87	88	87	90	
E1	85	86	88	87	91	
E2	87	87	88	87	90	
E3	87	90	88	90	90	
E4	87	86	88	88	88	
E5	86	86	87	86	87	
F1	88	87	90	91	90	
F2	87	88	87	91	88	
F3	87	87	88	91	90	
F4	87	86	88	90	88	
F5	87	88	87	88	90	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	129.26	29	4.4572414	1.9868832	0.0053446	1.562071
Within groups	269.2	120	2.2433333			
Total	398.46	149				
within-sd	1.4977761					
effective n	4.00					
s_bb	0.7439604					
s_bb_min	0.2690786					
u_bb	0.7439604					
u_bb(rel.)	0.8459863					

Tin:

	1	2	3	4	5	
A1	98	97	97	97	97	
A2	97	96	97	98	98	
A3	97	98	97	97	98	
A4	98	95	98	97	97	
A5	95	95	97	96	98	
B1	96	96	98	97	98	
B2	96	97	98	98	98	
B3	97	98	97	100	101	
B4	97	96	97	95	97	
B5	95	95	96	96	96	
C1	96	97	98	97	98	
C2	97	96	95	98	98	
C3	95	96	94	96	97	
C4	97	96	98	97	98	
C5	96	96	97	100	98	
D1	96	95	96	95	97	
D2	96	97	96	96	98	
D3	96	97	97	98	97	
D4	97	97	96	98	97	
D5	95	96	97	97	98	
E1	95	95	97	96	98	
E2	96	96	97	96	98	
E3	96	98	97	98	98	
E4	96	95	97	96	97	
E5	95	95	96	96	96	
F1	97	96	98	98	98	
F2	97	97	96	98	98	
F3	97	95	97	98	98	
F4	96	96	97	98	97	
F5	96	96	96	97	97	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	64.4	29	2.2206897	2.2281167	0.0013638	1.562071
Within groups	119.6	120	0.9966667			
Total	184	149				
within-sd	0.9983319					
effective n	4.00					
s_bb	0.5531779					
s_bb_min	0.1793524					
u_bb	0.5531779					
u_bb(rel.)	0.5714647					

Vanadium:

	1	2	3	4	5	
A1	152	145	145	146	149	
A2	147	145	146	148	148	
A3	147	147	145	148	148	
A4	147	142	147	147	146	
A5	143	142	146	145	147	
B1	145	146	149	147	149	
B2	144	146	149	149	148	
B3	145	152	147	149	155	
B4	145	143	144	142	145	
B5	142	142	144	142	146	
C1	147	147	148	146	150	
C2	144	144	145	148	150	
C3	142	143	140	145	144	
C4	145	146	149	147	150	
C5	143	143	146	149	148	
D1	145	145	145	143	148	
D2	144	147	144	146	149	
D3	144	147	146	148	148	
D4	145	146	145	148	147	
D5	142	144	147	145	150	
E1	142	142	146	144	150	
E2	144	145	146	144	146	
E3	145	150	146	148	150	
E4	144	143	145	145	147	
E5	141	143	144	144	144	
F1	145	144	147	150	150	
F2	145	148	145	150	149	
F3	145	143	145	150	149	
F4	145	143	145	147	147	
F5	144	146	143	145	147	
<i>Source of variation</i>	<i>sums of squares (SS)</i>	<i>degrees of freedom (df)</i>	<i>Mean squares (MS)</i>	<i>F-value</i>	<i>P-value</i>	<i>critical F-value</i>
Between groups	350.03333	29	12.070115	2.4938254	0.0002905	1.562071
Within groups	580.8	120	4.84			
Total	930.83333	149				
within-sd	2.2					
effective n	4.00					
s_bb	1.3444437					
s_bb_min	0.3952345					
u_bb	1.3444437					
u_bb(rel.)	0.9210621					

Zirconium:

	1	2	3	4	5
A1	100	98	99	99	99
A2	100	98	98	99	99
A3	100	100	99	100	100
A4	100	98	100	99	98
A5	99	99	99	98	99
B1	99	99	100	98	99
B2	99	99	100	101	99
B3	99	101	99	99	101
B4	98	98	98	98	99
B5	98	97	98	98	99
C1	100	99	100	99	100
C2	99	99	99	99	100
C3	98	98	97	98	98
C4	99	100	100	100	100
C5	98	99	99	99	99
D1	100	99	98	98	100
D2	99	99	98	99	100
D3	99	100	99	101	100
D4	100	99	98	100	99
D5	98	99	100	99	100
E1	99	99	99	98	100
E2	99	99	98	98	99
E3	99	101	99	100	100
E4	99	99	98	98	98
E5	98	98	98	98	98
F1	99	98	98	100	99
F2	100	100	98	99	100
F3	99	98	98	99	100
F4	100	99	98	100	100
F5	100	100	98	99	100

Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	46.433333	29	1.6011494	2.9835082	1.60373E-05	1.562071
Within groups	64.4	120	0.5366667			
Total	110.83333	149				
within-sd	0.7325754					
effective n	4.00					
s_bb	0.5158689					
s_bb_min	0.1316087					
u_bb	0.5158689					
u_bb(rel.)	0.5209043					

Annex 2: Calculation of uncertainty contribution of potential inhomogeneity (area)

($u_{bb}(\text{rel.})$ here means u_{bb} (rel) Length in Table 38)

The number of degrees of freedom (effective n) is calculated using the following equation

$$n = \frac{\sum_i g_i - (\sum_i g_i^2 / \sum_i g_i)}{i}$$

with

g_i = number of sparks per circle

i = number of circles (= 4: Centre, Inner, Middle, Outer)

Silicon:

															number of sparks i		
Centre	0.7148	0.7270													2		
Inner	0.7216	0.7174	0.7174	0.7238	0.7204	0.7159	0.7216	0.7154							8		
Middle	0.7260	0.7280	0.7223	0.7195	0.7198	0.7249	0.7209	0.7270	0.7252	0.7197	0.7240	0.7234			12		
Outer	0.7182	0.7104	0.7135	0.7141	0.7121	0.7115	0.7128	0.7072	0.7097	0.7111	0.7154	0.7120	0.7151	0.7169	0.7087	0.7125	16
<i>Source of variation</i>	<i>sums of squares (SS)</i>	<i>degrees of freedom (df)</i>	<i>Mean squares (MS)</i>	<i>F-value</i>	<i>P-value</i>	<i>critical F-value</i>											
Between groups	0.000846615	3	0.000282205	26.26184869	5.63798E-09	2.882604204											
Within groups	0.000365358		34	1.07458E-05													
Total	0.001211973		37														
within-sd	0.003278																
effective n	8.56																
s_{bb}	0.005631																
s_{bb_min}	0.000552																
u_{bb}	0.005631																
$u_{bb}(\text{rel.})$	0.784534																

Iron:

Copper:

Manganese:

Magnesium:

Chromium:

Nickel:

Zinc:

Titanium:

r_0	0.0270	0.0279					
r_in	0.0272	0.0276	0.0279	0.0276			
r_out	0.0273	0.0270	0.0270	0.0269			
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value	
Between groups	6.03335E-07	2	3.01668E-07	2.95555099	0.117346881	4.737414128	
Within groups	7.14477E-07	7	1.02068E-07				
Total	1.31781E-06	9					
within-sd	0.000319481						
effective n	3.20						
s_bb	0.00024975						
s_bb_min	0.000130573						
u_bb	0.00024975						
u_bb(rel.)	0.91393958						

Boron:

r_0	2.34	4.06				
r_in	3.42	2.46	2.64	3.59		
r_out	2.45	2.52	3.57	3.70		
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Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.04200675	2	0.021003375	0.039263091	0.961707915	4.737414128
Within groups	3.744575949	7	0.534939421			
Total	3.786582699	9				
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within-sd	0.73139553					
effective n	3.20					
s_bb	0					
s_bb_min	0.298923667					
u_bb	0.298923667					
u_bb(rel.)	9.7268941					

Beryllium:

r_0	6.93	7.08				
r_in	7.10	7.00	7.00	7.00		
r_out	7.10	7.10	7.20	7.10		
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Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.029	2	0.0145	3.866666667	0.073924703	4.737414128
Within groups	0.02625	7	0.00375			
Total	0.05525	9				
within-sd	0.061237244					
effective n	3.20					
s_bb	0.057960116					
s_bb_min	0.025027855					
u_bb	0.057960116					
u_bb(rel.)	0.82096481					

Bismuth:

r_0	80.18	81.82				
r_in	82.99	84.25	83.67	83.98		
r_out	82.46	82.56	83.66	83.12		
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	9.922644861	2	4.961322431	10.95661728	0.006982401	4.737414128
Within groups	3.169706134	7	0.452815162			
Total	13.092351	9				
within-sd	0.67291542					
effective n	3.20					
s_bb	1.186974524					
s_bb_min	0.275022661					
u_bb	1.186974524					
u_bb(rel.)	1.432336082					

Calcium:

Cadmium:

r_0	10.20	10.80				
r_in	10.58	11.03	10.79	10.96		
r_out	10.43	10.42	10.73	10.78		
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.200095417	2	0.100047708	1.747692488	0.242297444	4.737414128
Within groups	0.400719213	7	0.057245602			
Total	0.60081463	9				
within-sd	0.239260531					
effective n	3.20					
s_bb	0.115653181					
s_bb_min	0.097786536					
u_bb	0.115653181					
u_bb(rel.)	1.083622103					

Cobalt:

r_0	11.17	11.83				
r_in	11.50	11.80	11.30	11.70		
r_out	11.20	11.20	11.10	11.50		
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	0.2235	2	0.11175	1.741558442	0.243291335	4.737414128
Within groups	0.449166667	7	0.064166667			
Total	0.672666667	9				
within-sd	0.253311403					
effective n	3.20					
s_bb	0.121941755					
s_bb_min	0.103529172					
u_bb	0.121941755					
u_bb(rel.)	1.066857001					

Gallium:

Lithium:

Sodium:

Lead:

r_0	90.76	92.44				
r_in	91.73	92.17	90.92	91.90		
r_out	89.74	90.59	91.23	91.24		
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value
Between groups	2.194936528	2	1.097468264	2.045655747	0.199711458	4.737414128
Within groups	3.75541088	7	0.536487269			
Total	5.950347407	9				
within-sd	0.732452912					
effective n	3.20					
s_bb	0.418696263					
s_bb_min	0.299355823					
u_bb	0.418696263					
u_bb(rel.)	0.458735459					

Tin:

r_0	99.15	103.05					
r_in	100.50	103.60	102.30	102.00			
r_out	101.10	100.00	97.80	100.90			
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value	
Between groups	9.254	2	4.627	1.675437538	0.254345117	4.737414128	
Within groups	19.33166667	7	2.761666667				
Total	28.58566667	9					
within-sd	1.661826305						
effective n	3.20						
s_bb	0.763489795						
s_bb_min	0.679193669						
u_bb	0.763489795						
u_bb(rel.)	0.75563123						

Vanadium:

Centre	137.60	156.14															
Inner	150.97	149.29	144.45	146.26	141.77	149.83	142.51	148.01									
Middle	143.06	144.05	140.94	142.76	146.59	147.94	140.80	144.58	142.37	143.59	143.86	147.40					
Outer	137.90	143.55	158.28	144.56	143.65	142.09	145.35	146.36	149.71	144.59	139.98	142.53	139.88	140.91	139.59	139.47	
Source of variation	sums of squares (SS)	degrees of freedom (df)	Mean squares (MS)	F-value	P-value	critical F-value											
Between groups	62.28028684	3	20.76009561	1.033741672	0.389987276	2.882604204											
Within groups	682.8042921	34	20.08247918														
Total	745.0845789	37															
within-sd	4.481348																
effective n	8.56																
s_bb	0.281332																
s_bb_min	0.754265																
u_bb	0.754265																
u_bb(rel.)	0.522240																

Zirconium:

Centre	109.72	120.78																
Inner	118.29	115.01	113.50	113.06	112.46	116.68	111.36	114.88										
Middle	114.77	114.13	112.25	111.98	114.83	114.18	110.88	113.66	113.01	113.13	112.83	114.07						
Outer	110.73	112.90	119.00	113.48	113.62	110.94	113.56	114.12	114.15	113.53	110.83	111.09	112.43	111.03	111.62	111.24		
<i>Source of variation</i>	<i>sums of squares (SS)</i>	<i>degrees of freedom (df)</i>	<i>Mean squares (MS)</i>	<i>F-value</i>	<i>P-value</i>	<i>critical F-value</i>												
Between groups	21.42856414	3	7.142854715	1.353865204	0.273370452	2.882604204												
Within groups	179.3805318	34	5.275897993															
Total	200.8090959	37																
within-sd	2.296932																	
effective n	8.56																	
s_bb	0.466976																	
s_bb_min	0.386601																	
u_bb	0.466976																	
u_bb(rel.)	0.412116																	