Certification Report

Certified Reference Material

BAM-S006

Multielement Glass

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Summary

This report describes preparation, analysis and certification of the multielement glass reference material BAM-S006. The certified reference material (CRM) is available in the form of discs (38 mm diameter and 4 mm height) and in form of cullet. BAM-S006 is intended for establishing and checking the calibration of X-ray spectrometers 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 fraction [1] in %		Uncertainty [2] in %
Al	(Al_2O_3)	1.081	(2.042)	0.015
Ca	(CaO)	7.660	(10.72)	0.016
Mg	(MgO)	1.163	(1.929)	0.010
Na	(Na_2O)	8.79	(11.85)	0.11
K	(K_2O)	0.577	(0.695)	0.008
Fe	(Fe_2O_3)	0.468	(0.669)	0.008
Cr	(Cr_2O_3)	0.382	(0.558)	0.006
Mn	(MnO)	0.213	(0.275)	0.004
Si	(SiO_2)	33.10	(70.83)	0.12
		in mg/kg		**in mg/kg**
As	(As_2O_3)	9.0	(11.8)	1.7
Ba	(BaO)	456	(509)	23
Cd	(CdO)	0.21	(0.24)	0.06
Co	(CoO)	172	(219)	5
Ni	(NiO)	19.3	(24.6)	1.4
P	(P_2O_5)	85	(195)	16
Pb	(PbO)	103	(111)	5
S	(SO_3)	201	(502)	9
Sb	(Sb_2O_3)	10.8	(12.9)	1.5
Ti	(TiO_2)	391	(652)	6

[1] Unweighted mean value of the means of accepted sets of data (consisting of at least 1 single results), each set being obtained by a different laboratory and/or a different method of measurement. The values in brackets were calculated from the mass fractions of the elements using the atomic weights.

[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). The stated measurement uncertainties refer only to the mass fractions of the elements.

Values for Information

Element		Mass fraction [1] in mg/kg		Uncertainty [2] in mg/kg
Cl		180		28
Cu	(CuO)	26	(33)	10
Sr	(SrO)	130	(154)	82
Zn	(ZnO)	61	(76)	7
Zr	(ZrO_2)	139	(188)	28

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.
The certified values are based on the results of eighteen laboratories which participated in the certification inter-laboratory comparison.

Content

List of abbreviations
(if not explained elsewhere)

CRM	certified reference material
T_G	glass transition or softening temperature
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
XRF	X-ray fluorescence spectrometry
DGG	Deutsche Glastechnische Gesellschaft
ICG	International Commission on Glass
M	mean value
n	number of accepted data sets
s	standard deviation of an individual data set
s_M	standard deviation of laboratory means
s_{rel}	relative standard deviation
$\bar{s}_i$	square root of mean of variances of data sets under repeatability conditions
M_i	single result
Comb.	Combustion/Infrared detection (Tables 2 – 25)
I	ICP-OES (Tables 2 – 25)
IMS	ICP-MS (Tables 2 – 25)
A	FAAS (Tables 2 – 25)
EA	ETAAS (Tables 2 – 25)
G	gravimetry (Tables 2 – 25)
LA-MS	Laser ablation coupled with ICP-MS (Tables 2 – 25)
XRF	X-ray fluorescence spectrometry (Tables 2 – 25)
(R)	revised value

1. Introduction

Soda-lime glass is one of the worldwide mostly distributed mass-produced articles and is of enormous technical and economic importance. The impurities in soda-lime glasses come from the intake by raw materials and from production process. They influence the properties of the glass and, therefore, their mass fractions must not exceed defined limit values. The analytical method of X-ray fluorescence spectrometry (XRF) is a powerful tool of effective determination of trace contents of most elements in soda-lime glass at the relevant level of mass fractions. The advantage of this method is that the samples can be measured directly without applying time consuming chemical procedures of sample digestion, but it requires reference materials with similar composition as the samples to be analysed. The aim of the certification process described here was to prepare a reference material with certified mass fractions of a few heavy metals such as lead which are regulated. The CRM can be used to support the XRF-evaluation program basing on fundamental parameter approach by a definite calibration point for each of the relevant trace elements. Thus, the semi-quantitative character of the evaluation procedure can be improved and changed to a quantitative one. In total 13 trace elements and nine main components were analysed in the certification interlaboratory comparison organised to characterise BAM-S006.

The CRM was characterised in cooperation with the working group „UA-Glasanalyse“ within Deutsche Glastechnische Gesellschaft e.V. (DGG) and the Technical Committee 02 “Durability & Analysis” of the International Commission on Glass (ICG). Since all the laboratories participating in this certification project are highly experienced with glass 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:

– Zentrum für Glas- und Umweltanalytik GmbH, Ilmenau-Unterpörlitz, Germany

Test for homogeneity:

– Zentrum für Glas- und Umweltanalytik GmbH, Ilmenau-Unterpörlitz, Germany
– Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany

Participants in the certification inter-laboratory comparison:

Ardagh Glass Packaging - Europe, Nienburg/Weser, Germany
Bundesanstalt für Materialforschung und -prüfung (BAM), Berlin, Germany
Cetim, Illkirch-Graffenstaden, France
Corning European Technology Center (CETC), S&T European Laboratory, Fontainebleau, France
Corning US, Corning, NY, USA
Glashütte Freital GmbH, Freital, Germany
Glass Technology Services Ltd, Sheffield, South Yorkshire, United Kingdom
IGR Institut für Glas- und Rohstofftechnologie GmbH, Göttingen, Germany
INISMa (Institut Interuniversitaire des Silicates, Sols et Matériaux, Mons, Belgium
NSG, Lathom, United Kingdom
Schott AG, Jena, Germany
Schott AG, Mainz, Germany
Stazione Sperimentale del Vetro, Murano, Italy

Saint-Gobain Sekurit Deutschland GmbH, Herzogenrath, Germany
Stoelzle Oberglas GmbH, Köflach, Austria
T. Şişe ve Cam Fab. A.Ş. Science and Technology Center, Gebze Kocaeli, Turkey
Wiegand-Glashüttenwerke GmbH, Steinbach am Wald, Germany
Zentrum für Glas- und Umweltanalytik GmbH, Ilmenau-Unterpörlitz, Germany

Statistical evaluation of the data:

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

3. Candidate material

The candidate material was produced by Zentrum für Glas- und Umweltanalytik GmbH, Ilmenau-Unterpörlitz [4], from commercially available green champagne bottles (Ardagh Glass Packaging – Europe). The bottles were broken into small pieces. In each case, 11.5 kg of cullet were thawed in four deposits each in a medium-frequency heated run-out unit at temperatures of 1200 °C to 1400 °C. The molten glass was then refined at temperatures up to 1470 °C and homogenised by stirring. The total duration of the melts, the exact sequence of which was documented, was seven hours. A total of four melts were carried out.
The casting was done in a preheated stainless-steel mould. After rapid cooling in air to near T_G, the glass block with mould was placed in an annealing furnace and cooled to room temperature at a rate of 1 K/min, starting at an initial temperature of 590 °C.
Four blocks of black-appearing glass (10 – 11 kg each) were obtained. The blocks are irregularly shaped (no sharp edges) because the viscosity was slightly too high during casting. Higher temperatures, which would have lowered the viscosity, were not possible because preliminary tests had shown that the glass then tended to stick to the mould, which would have destroyed the blocks.
From the obtained glass blocks, 1000 pieces of XRF tablets with diameter 40 mm were obtained by dividing, drilling out and grinding and polishing on one side.
The remaining material for the granulate was heated (200°C) and quenched in water. This was followed by crushing in a jaw crusher, sieving to > 1 mm, magnetic treatment, washing several times in distilled water and drying at approx. 150°C. The total yield was approx. 4.6 kg of granules > 1 mm.

4. Homogeneity testing

The glass discs were tested for homogeneity using wavelength dispersive X-ray fluorescence. In total 20 randomly taken discs were analysed. One of these discs was used as drift control sample and to determine the spread coming from the analytical method. This is easily possible because XRF is a non-destructive method. The drift control sample was measured six times in the beginning and then after every eleventh measurement. For none of the elements a drift correction was necessary. Each disc was measured three times.

The estimate of analyte-specific inhomogeneity contribution ubb to be included into the total uncertainty budget was calculated using Eq. (1) and Eq. (2):

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

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

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}.

Annex 1 shows the results of the homogeneity calculations.

5. Characterisation study

5.1 Analytical methods

18 laboratories participated in the certification inter-laboratory comparison. All laboratories were highly experienced in the analysis of glass and participated successfully in former inter-laboratory comparisons carried out by ICG. 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 four subsamples. They were free to choose any suitable analytical method. Table 2 shows the analytical methods used by the participating laboratories.

For wet chemical 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. Calibration of solid sampling methods were not in all cases performed with pure metals or stoichiometric compounds or well checked commercial calibration solutions but also with matrix CRMs (e.g. BAM-S005a/b/c).

Table 1: Analytical procedures used by the participating laboratories

Lab-No.	Element	Sample mass	Sample pretreatment	Analytical method
1	Cr, Pb, Mn, Ni, Al, Ca, Fe, Mg, Na, K, Si, Ti, Ba, Sr, S		Polishing of the compact glass sample	XRF (acc. to DIN 51001) against Standardglas II of DGG and several glass standards produced by the laboratory and characterized in an interlaboratory comparison
2	Cr, Mn, Ni, Co	0.2 g	Dissolution with HF/HNO_3	ICP-OES, calibration with commercial calibration solutions (VWR, Perkin Elmer, Spex)
	Al, Ca, Fe, Mg, Na, K, Si		Polishing of the compact glass sample	XRF against several glass standards verified against NIST SRM 1831
	S	0.2 g		Combustion/Infrared detection, calibration with K_2SO_4 (flux: 1 g W/Sn + 0.75 g Fe)
3	As, Sb	0.1 g	Dissolution with HF/HNO_3, Microwave digestion	ICP-MS, standard addition calibration with commercial calibration solutions
	Cd	1 g	Dissolution with HF/HNO_3/ $HClO_4$	ICP-MS, standard addition calibration with commercial calibration solutions
	Co	0.1 g	Dissolution with HF/HNO_3, Microwave digestion	ICP-OES, standard addition calibration with commercial calibration solutions
	Pb, Mn, Cr, Ni	1 g	Dissolution with HF/HNO_3/ $HClO_4$	ICP-OES, standard addition calibration with commercial calibration solutions
	Al, Ca, Fe, Mg, Na, K, Si		Polishing of the compact glass sample	XRF, calibration with NIST 420, 621, 1830, 1831, BR 1-S (Breitländer), CRM 4004, 4005, 4006, 4007 (Czech Metrology Center), Standard Glass No. 6 and 7 and SCT 10 and 11 (Society of Glass Technology)
4*	Cr, Al, Fe, Mg, Na, K	0.5 g	Dissolution with acid	ICP-OES, calibration with commercial calibration solutions
	Si	1 g	Dissolution with acid	Gravimetry
5	Cr	1 g	Dissolution with HF/$HClO_4$	FAAS, calibration with commercial calibration solutions (Merck)
	Mg	0.2 g	Dissolution with HF/$HClO_4$	FAAS, calibration with commercial calibration solutions (Merck)
	Na, K	0.1 g	Dissolution with HF/$HClO_4$	FAAS, calibration with commercial calibration solutions (Merck)
6*	As, Cr, Cd, Pb, Mn, Ni, Sb, Co			ICP-OES, calibration with certified reference solutions
	Cr, Mn, Al, Ca, Fe, Mg, Na, K, Si, Ba, P, Ti, Sr		Polishing of the compact glass sample	XRF
7*	Na, K	0.15 g	Dissolution with HF/$HClO_4$	FAAS calibration with commercial mono-element solutions (Alfa Aesar
	As. Cr, Cd, Pb, Ni, Sb, Co, Fe, K			LA-ICP-MS calibration with different glass CRMs
	Cr, Pb, Mn, Al, Ca, Fe, Mg, Na, K, Ba, S, Ti, Zr, Sr, P, Cl			XRF, calibration with different glass CRMs
9	As. Cd, Ni, Sb	2 g	Hot digestion (HF/HCl-HCl/HNO_3-HCl) - Digiblock	ICP-MS, calibration with commercial mono-element solutions (Merck)

*accredited acc. to ISO 17025

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

Lab-No.	Element	Sample mass	Sample pretreatment	Analytical method
9	Cr, Pb, Mn, Co, Fe	2 g	Hot digestion (HF/HCl-HCl/HNO_3-HCl) - Digiblock	ICP-OES, calibration with commercial mono-element solutions and internal standard (Y) (Merck)
	Al, Ca, Mg, Na, K, Si			XRF, calibration with glass CRMs NIST SRM 620 + 621
10	Cr, Cd, Pb, Mn, Ni, Co	0.1 g	Dissolution with HF/HNO_3	ICP-OES, calibration with commercial certified mono-element solutions (SPC Science, traceable to NIST)
	As, Sb	0.5 g	Dissolution with HF/HNO_3 (autoclave)	ICP-OES, calibration with commercial certified mono-element solutions (SPC Science, traceable to NIST)
	Al, Ca, Fe, Mg, Na, K, Si, Cr, Pb, Ti, Zr, Ba	1.4 g	Bead with $Li_2B_4O_7$	XRF (ISO 12677), calibration with CRMs
11*	As, Cr, Cd, Pb, Ni, Sb, Co, Al, Ca, Fe, Mg, Na, K	0.5 g	Dissolution with $HClO_4$/HF/HNO_3, fuming with $HClO_4$ acc. to DIN 52340 Method C	ICP-OES, calibration with commercial mono-element solutions (Merck certipur)
	Cd	0.5 g		ETAAS, calibration with commercial mono-element solutions (Merck certipur)
	S	0.2 g		Combustion/Infrared detection, calibration with BAM-S005a
12*	As, Cr, Cd, Pb, Ni, Sb, Co, Al, Ca, Fe, Mg, K	0.1 g	Dissolution with HF/HNO_3 acc. to DIN 52340-3	ICP-OES acc. to DIN 51086-2, calibration with matrix matched standards, commercial standard solutions
	As, Cr, Cd, Pb, Ni, Sb, Co, Al, Ca, Fe, Mg, K, Cl, Ba, Ti, Zr, Zn, Sr, S, Cu			XRF acc. to DIN 51001
13*	As. Cr, Cd, Pb, Ni, Sb, Co, Al, Ca, Fe, Mg, Na, K, Si, Sr, Ba, Ti, S	0.3 g	Dissolution with HF/$HClO_4$	ICP-OES, calibration with commercial mono-element solutions (NIST traceable)
14*	As, Cd, Mn, Ni, Sb, Co	0.25 g		ICP-OES, calibration with commercial mono-element solutions
	Cr, Al, Ca, Fe, Mg, Na, K, Si, Cl, Ba, Ti, Zr, Zn, S, Cu			XRF acc. to DIN 51001
15	Cr, Pb, Ni, Sb, Co, Al, Ca, Fe, Mg, Na, K, S, Cl, Ti, Cu, Zn, Sr, Zr, Ba			WLD-XRF, calibration with several glass CRMs among others BAM-S005a/b, NIST SRM 620 and 1830, DGG-1 and -2
16	As, Cd, Pb, Ni, Sb		Dissolution with acid	ICP-MS
	Cr, Mn		Dissolution with acid	ICP-OES
	Al, Ca, Fe, Mg, Na, K, Si			XRF
17	As, Cr, Cd, Pb, Sb, Al, Ca, Na, K, P, S, Cl, Cu, Zn, Zr, Ba			XRF, calibration with several glass CRMs among others BAM-S005a, BCR-664, DGG-1 and -2
18	Pb, Ni	0.1 g	Dissolution with HF/HNO_3 (microwave)	ICP-OES, calibration with commercial standard solutions
	Cr, Mn, Al, Ca, Fe, Mg, Na, K, Si, Ba, Ti, Zr, Cu, P, Sr			XRF, calibration with several glass CRMs among others BAM-S005C, BCR 664, NIST 610,612 und 620
19	Cr, Cd, Pb, Mn, Ni, Co	0.5 g	Dissolution with acid acc. to DIN 51086-2	ICP-OES, calibration with commercial standard solutions
	Al, Ca, Mg, Fe, Na, K, Si, Ba, S, Ti, Zr, Sr, P, Cl			XRF

*accredited acc. to ISO 17025

5.2 Analytical results and statistical evaluation

The analytical results of the inter-laboratory certification comparison are listed in Tables 2 to 25. 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 Al

Lab./Meth.	6/XRF	9/XRF	4/I	10/XRF	2/XRF	16/XRF	7/XRF	14/XRF	11/I	15/XRF	12/XRF	1/XRF	12/I	3/XRF	18/XRF	17/XRF(R)	19/XRF	13/I		
M_i [%]	1.021	1.047	1.040	1.061	1.075	1.080	1.095	1.090	1.086	1.088	1.087	1.094	1.181	1.096	1.100	1.099	1.096	1.085		*n*
	1.032		1.050	1.061	1.075	1.079	1.097	1.080	1.089	1.086	1.087	1.090	1.054	1.096	1.100	1.100	1.106	1.096		18
	1.016		1.100	1.063	1.075	1.078	1.070	1.080	1.068	1.085	1.087	1.094	1.104	1.090	1.090	1.100	1.080	1.095		
	1.021		1.050	1.062	1.080	1.080	1.068	1.080	1.096	1.087	1.088		1.037	1.096	1.090	1.100	1.138	1.148		
M [%]	**1.023**	**1.047**	**1.060**	**1.062**	**1.076**	**1.079**	**1.082**	**1.083**	**1.085**	**1.087**	**1.087**	**1.093**	**1.094**	**1.094**	**1.095**	**1.100**	**1.105**	**1.106**		**1.081**
s [%]	0.007		0.027	0.001	0.003	0.001	0.016	0.005	0.012	0.001	0.000	0.002	0.065	0.003	0.006	0.001	0.024	0.028	s_M [%]	0.021
																			$\bar{s}_i$ [%]	0.0195
s_{rel}	0.0065		0.0255	0.0010	0.0025	0.0011	0.0144	0.0046	0.0113	0.0012	0.0003	0.0021	0.0590	0.0024	0.0053	0.0005	0.0221	0.0257		0.0197

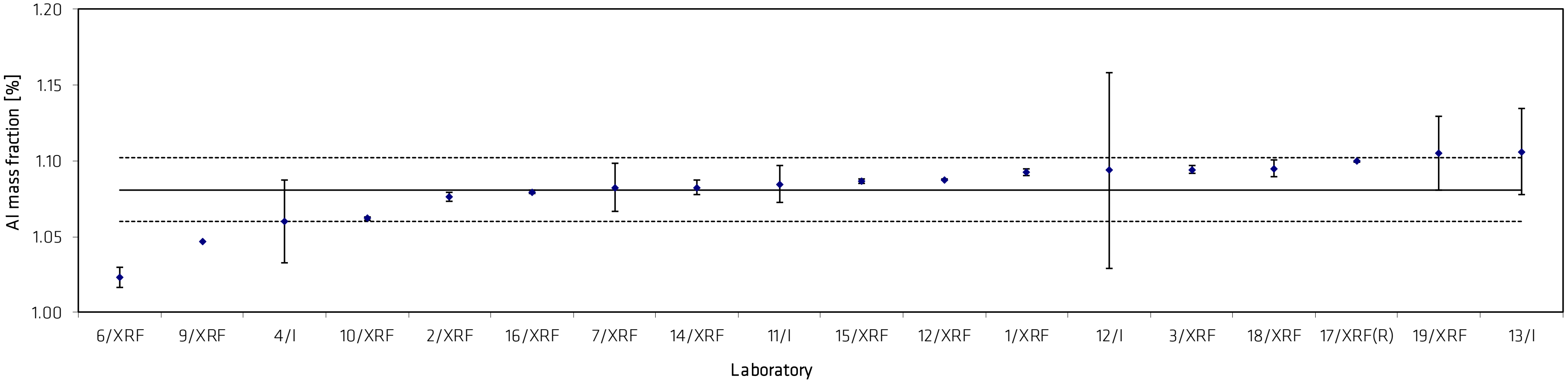


Table 3: Results for Ca

Lab./Meth.	15/XRF	19/XRF	12/XRF	9/XRF	12/I	13/I	7/XRF	2/XRF	3/XRF	17/XRF(R)	16/XRF	10/XRF	18/XRF	14/XRF	6/XRF	1/XRF		
M_i [%]	7.642	7.569	7.636	7.640	7.694	7.604	7.704	7.665	7.669	7.672	7.683	7.707	7.669	7.730	7.775	7.769		*n*
	7.617	7.626	7.631		7.582	7.649	7.705	7.665	7.676	7.676	7.676	7.690	7.690	7.710	7.752	7.764		16
	7.609	7.633	7.637		7.642	7.704	7.611	7.658	7.676	7.676	7.676	7.669	7.690	7.700	7.775	7.775		
	7.607	7.647	7.627		7.694	7.659	7.614	7.665	7.676	7.676	7.676	7.652	7.676	7.700	7.761			
M [%]	**7.619**	**7.619**	**7.633**	**7.640**	**7.653**	**7.654**	**7.659**	**7.663**	**7.674**	**7.675**	**7.678**	**7.680**	**7.681**	**7.710**	**7.766**	**7.769**		**7.660**
s [%]	0.0161	0.0343	0.0050		0.0533	0.0410	0.0533	0.0036	0.0036	0.0020	0.0036	0.0237	0.0107	0.0141	0.0111	0.0055	s_M [%]	0.0259
																	$\bar{s}_i$ [%]	0.0264
s_{rel}	0.00211	0.00450	0.00065		0.00697	0.00535	0.00695	0.00047	0.00047	0.00026	0.00047	0.00309	0.00140	0.00183	0.00144	0.00071		0.00338

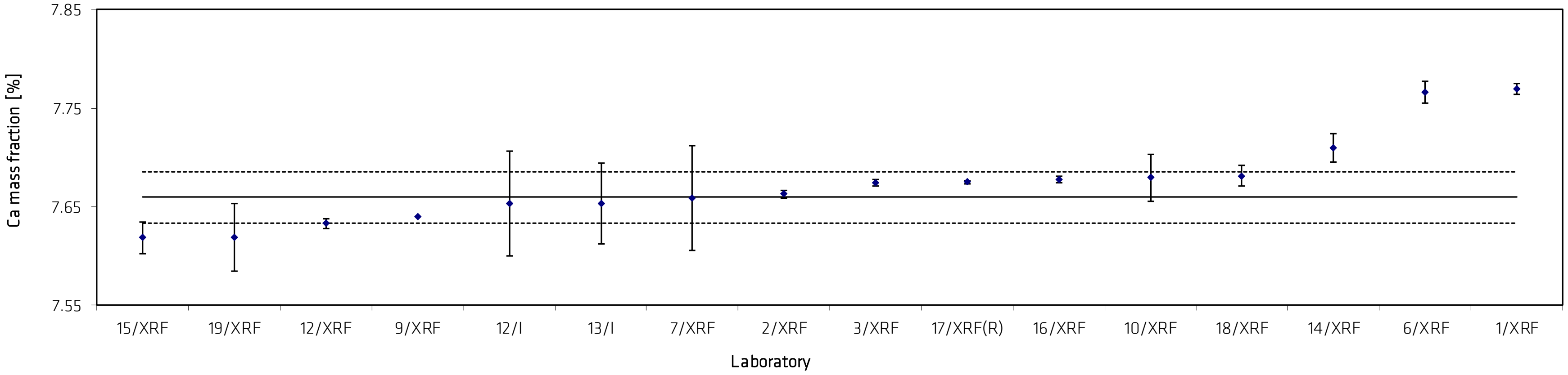


Table 4: Results for Mg

Lab./Meth.	11/I	13/I	2/XRF	6/XRF	10/XRF	15/XRF	12/XRF	12/I	16/XRF	19/XRF	7/XRF	3/XRF	4/I	18/XRF	14/XRF	5/A	9/XRF	1/XRF		
M_i [%]	1.133	1.137	1.146	1.146	1.154	1.149	1.156	1.164	1.162	1.164	1.172	1.164	1.190	1.170	1.180	1.166	1.188	1.199		*n*
	1.131	1.147	1.140	1.146	1.156	1.153	1.156	1.150	1.162	1.182	1.174	1.164	1.160	1.160	1.180	1.188		1.193		18
	1.147	1.147	1.146	1.146	1.144	1.157	1.156	1.170	1.165	1.152	1.155	1.170	1.170	1.180	1.170	1.173		1.198		
	1.148	1.142	1.146	1.146	1.151	1.152	1.155	1.167	1.162	1.158	1.157	1.170	1.160	1.180	1.170	1.175				
M [%]	**1.140**	**1.143**	**1.145**	**1.146**	**1.151**	**1.153**	**1.156**	**1.162**	**1.163**	**1.164**	**1.164**	**1.167**	**1.170**	**1.173**	**1.175**	**1.175**	**1.188**	**1.197**		**1.163**
s [%]	0.0091	0.0046	0.0030	0.0000	0.0053	0.0033	0.0005	0.0088	0.0012	0.0130	0.0096	0.0035	0.0141	0.0096	0.0058	0.0091		0.0032	s_M [%]	0.0155
																			$\bar{s}_i$ [%]	0.0072
s_{rel}	0.0080	0.0040	0.0026	0.0000	0.0046	0.0029	0.0004	0.0076	0.0010	0.0111	0.0083	0.0030	0.0121	0.0082	0.0049	0.0078		0.0027		0.0133

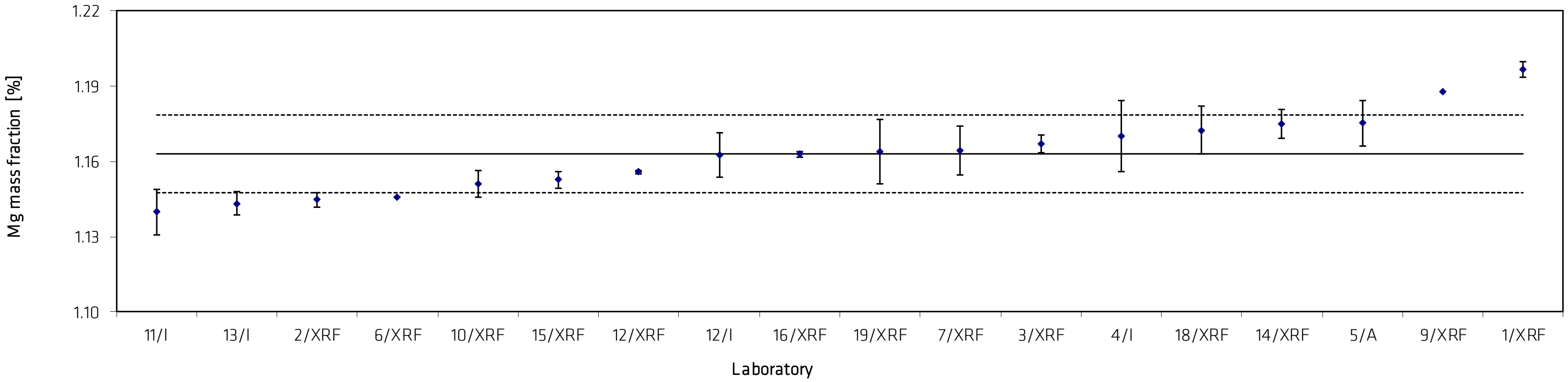


Table 5: Results for Na

Lab./Meth.	16/XRF	7/A	7/XRF	4/I	2/XRF	14/XRF	6/XRF	18/XRF	1/XRF	17/XRF(R)	15/XRF	12/XRF	11/I	10/XRF	3/XRF	13/I	5/A	9/XRF	19/XRF		
M_i [%]	8.651	8.670	8.659	8.88	8.753	8.79	8.789	8.78	8.794	8.794	8.769	8.799	8.725	8.875	8.865	8.778	8.865	8.925	9.422		*n*
	8.651	8.663	8.675	8.68	8.753	8.77	8.775	8.79	8.812	8.798	8.811	8.802	8.885	8.845	8.858	8.851	8.900		9.347		19
	8.651	8.762	8.773	8.76	8.753	8.73	8.769	8.80	8.782	8.801	8.817	8.806	8.677	8.807	8.865	8.893	8.917		9.347		
	8.643	8.717	8.765	8.67	8.753	8.74	8.773	8.79		8.809	8.809	8.803	8.953	8.792	8.858	8.959	8.887		9.422		
M [%]	8.649	8.703	8.718	8.748	8.753	8.758	8.776	8.790	8.796	8.801	8.802	8.803	8.810	8.830	8.861	8.870	8.892	8.925	9.385		8.794
s [%]	0.0037	0.0461	0.0591	0.0971	0.0000	0.0275	0.0088	0.0082	0.0151	0.0063	0.0219	0.0031	0.1304	0.0375	0.0042	0.0757	0.0219		0.0433	s_M [%]	0.0684
																				$\bar{s}_i$ [%]	0.0479
s_{rel}	0.00043	0.00529	0.00678	0.01110	0.00000	0.00314	0.00100	0.00093	0.00172	0.00072	0.00249	0.00035	0.01480	0.00425	0.00048	0.00854	0.00247		0.00461		0.00778

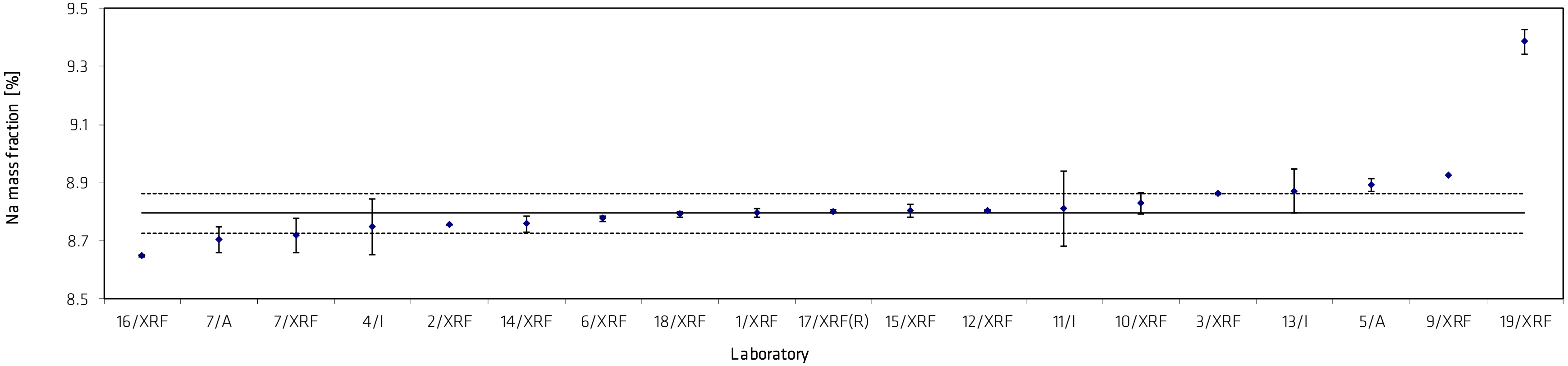


Table 6: Results for K

Lab./Meth.	7/A	19/XRF	1/XRF	7/LA-MS	15/XRF	12/XRF	11/I	13/I	18/XRF	17/XRF(R)	9/XRF	7/XRF	2/XRF	10/XRF	4/I	14/XRF	3/XRF	16/XRF	5/A	6/XRF	12/I		
M_i [%]	0.552	0.551	0.55	0.562	0.569	0.564	0.5691	0.566	0.581	0.575	0.580	0.594	0.581	0.583	0.599	0.590	0.598	0.580	0.591	0.598	0.6216		*n*
	0.548	0.546	0.55	0.567	0.562	0.565	0.5666	0.572	0.573	0.576		0.595	0.581	0.584	0.578	0.590	0.598	0.599	0.599	0.598	0.6202		21
	0.545	0.545	0.55	0.563	0.562	0.566	0.5638	0.566	0.573	0.577		0.565	0.581	0.580	0.580	0.590	0.589	0.597	0.597	0.598	0.6257		
	0.550	0.555		0.557	0.563	0.565	0.5635	0.581	0.573	0.577		0.566	0.581	0.579	0.570	0.590	0.598	0.596	0.594	0.598	0.6179		
M [%]	**0.549**	**0.549**	**0.550**	**0.562**	**0.564**	**0.565**	**0.566**	**0.571**	**0.575**	**0.576**	**0.580**	**0.580**	**0.581**	**0.581**	**0.582**	**0.590**	**0.596**	**0.593**	**0.595**	**0.598**	**0.621**		**0.577**
s [%]	0.0030	0.0046	0.0000	0.0041	0.0034	0.0009	0.0026	0.0071	0.0042	0.0006		0.0168	0.0000	0.0020	0.0123	0.0000	0.0042	0.0086	0.0036	0.0000	0.0033	s_M [%]	0.0181
																						$\bar{s}_i$ [%]	0.0057
s_{rel}	0.00544	0.00846	####	0.00722	0.00597	0.00160	0.00466	0.01242	0.00722	0.00102		0.02892	####	0.00343	0.02112	####	0.00697	0.01456	0.00606	####	0.00527		0.03139

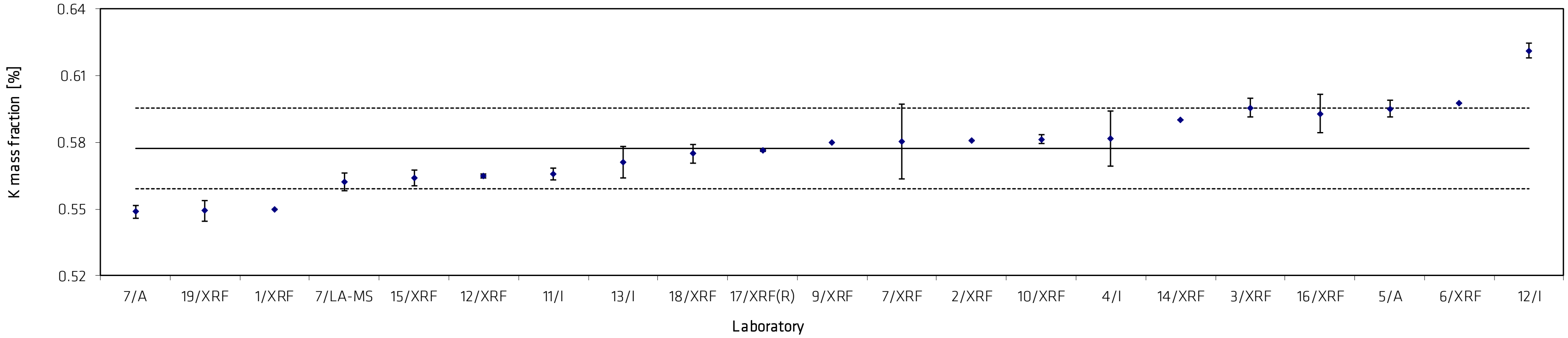


Table 7: Results for Fe

Lab./Meth.	3/XRF	4/I	9/I	7/LA-MS	7/XRF	12/I	16/XRF	12/XRF	13/I	19/XRF	11/I	10/XRF	15/XRF	2/XRF	18/XRF	14/XRF	1/XRF	6/XRF		
M_i [%]	0.428	0.438	0.443	0.455	0.449	0.467	0.469	0.470	0.474	0.478	0.480	0.475	0.479	0.482	0.478	0.490	0.482	0.494		*n*
	0.426	0.444	0.448	0.456	0.449	0.461	0.469	0.471	0.475	0.472	0.474	0.476	0.475	0.475	0.476	0.480	0.484	0.496		18
	0.430	0.450	0.448	0.453	0.471	0.466	0.470	0.471	0.468	0.476	0.471	0.475	0.475	0.475	0.478	0.480	0.486	0.481		
	0.430	0.440		0.444	0.472	0.459	0.469	0.470	0.473	0.472	0.475	0.475	0.474	0.475	0.478	0.480		0.487		
M [%]	**0.428**	**0.443**	**0.446**	**0.452**	**0.461**	**0.463**	**0.469**	**0.471**	**0.473**	**0.475**	**0.475**	**0.475**	**0.476**	**0.477**	**0.478**	**0.483**	**0.484**	**0.489**		**0.468**
s [%]	0.0019	0.0053	0.0024	0.0055	0.0129	0.0036	0.0003	0.0006	0.0030	0.0030	0.0041	0.0005	0.0022	0.0035	0.0010	0.0050	0.0020	0.0070	s_M [%]	0.0160
																			$\bar{s}_i$ [%]	0.0046
s_{rel}	0.00442	0.01196	0.00547	0.01225	0.02806	0.00788	0.00074	0.00128	0.00632	0.00632	0.00861	0.00096	0.00466	0.00733	0.00207	0.01036	0.00413	0.01432		0.03417

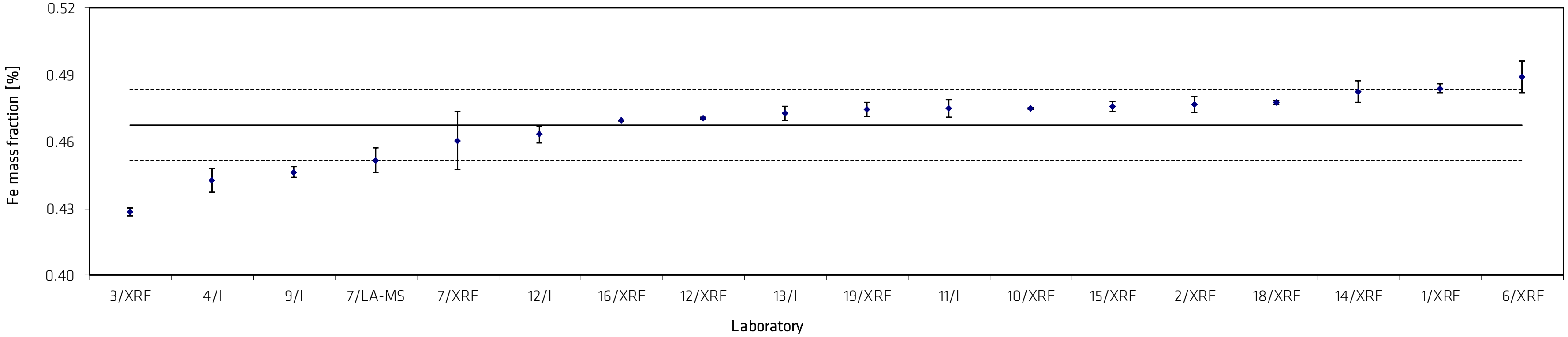


Table 8: Results for Cr

Lab./Meth.	7/LA-MS	7/XRF	13/I	19/I	9/I	4/I	3/I	16/I	1/XRF	14/XRF	12/I	10/I	10/XRF	2/I	15/XRF	12/XRF	18/XRF	6/XRF	5/A	17/XRF(R)		
M_i [%]	0.316	0.324	0.36	0.366	0.369	0.370	0.372	0.3823	0.381	0.384	0.383	0.380	0.387	0.386	0.389	0.390	0.390	0.390	0.396	0.404		*n*
	0.319	0.325	0.35	0.367	0.372	0.372	0.366	0.3818	0.382	0.383	0.384	0.387	0.385	0.387	0.388	0.389	0.389	0.389	0.392	0.404		20
	0.319	0.321	0.36	0.363	0.371	0.381	0.377	0.3794	0.383	0.382	0.385	0.388	0.388	0.389	0.387	0.389	0.389	0.391	0.392	0.404		
	0.324	0.320	0.3500	0.366		0.371	0.385	0.3838		0.382	0.384	0.384	0.387	0.389	0.387	0.390	0.391	0.390	0.399	0.404		
M [%]	**0.319**	**0.322**	**0.353**	**0.365**	**0.371**	**0.373**	**0.375**	**0.382**	**0.382**	**0.383**	**0.384**	**0.385**	**0.387**	**0.388**	**0.388**	**0.389**	**0.390**	**0.390**	**0.395**	**0.404**		**0.382**
s [%]	0.0032	0.0022	0.0034	0.0017	0.0016	0.0050	0.0079	0.0018	0.0011	0.0008	0.0008	0.0037	0.0012	0.0016	0.0010	0.0007	0.0010	0.0007	0.0032	0.0003	s_M [%]	0.0117
																					$\bar{s}_i$ [%]	0.0028
s_{rel}	0.00992	0.00673	0.00959	0.00471	0.00439	0.01350	0.02112	0.00483	0.00292	0.00212	0.00219	0.00957	0.00318	0.00408	0.00247	0.00190	0.00246	0.00181	0.00820	0.00065		0.03062

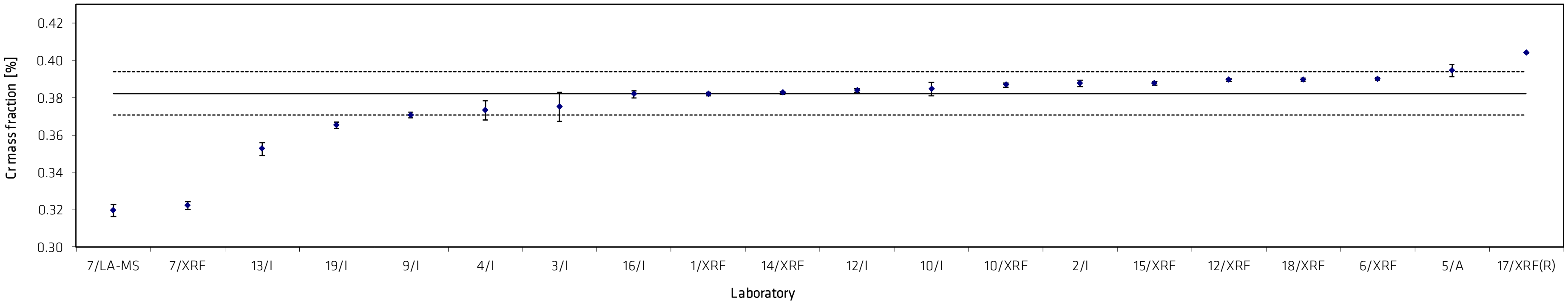


Table 9: Results for Mn

Lab./Meth.	19/I	9/I	11/I	6/I	3/I	10/I	14/IMS	13/I	2/I	12/I	16/I	6/XRF	7/XRF	12/XRF	1/XRF	18/XRF	15/XRF		
M_i [%]	0.201	0.20	0.202	0.204	0.205	0.205	0.2107	0.215	0.216	0.213	0.216	0.217	0.213	0.220	0.221	0.223	0.230		*n*
	0.201	0.20	0.204	0.203	0.210	0.210	0.2122	0.215	0.215	0.213	0.216	0.217	0.213	0.220	0.221	0.223	0.229		17
	0.200	0.20	0.202	0.204	0.211	0.211	0.2137	0.212	0.214	0.217	0.213	0.217	0.222	0.220	0.222	0.223	0.229		
	0.201		0.202	0.202	0.209	0.209	0.2114	0.215	0.213	0.218	0.216	0.217	0.221	0.220		0.223	0.228		
***M* [%]**	**0.201**	**0.202**	**0.202**	**0.203**	**0.209**	**0.209**	**0.212**	**0.214**	**0.214**	**0.215**	**0.215**	**0.217**	**0.217**	**0.220**	**0.221**	**0.223**	**0.229**		**0.213**
s [%]	0.0006	0.0012	0.0009	0.0007	0.0026	0.0026	0.0013	0.0016	0.0014	0.0027		0.0000	0.0046	0.0002	0.0009	0.0000	0.0008	s_M [%]	0.0080
																		$\bar{s}_i$ [%]	0.0018
s_{rel}	0.00284	0.00613	0.00456	0.00325	0.01263	0.01268	0.00608	0.00746	0.00663	0.01277		0.00000	0.02120	0.00101	0.00418	0.00000	0.00357		0.03772

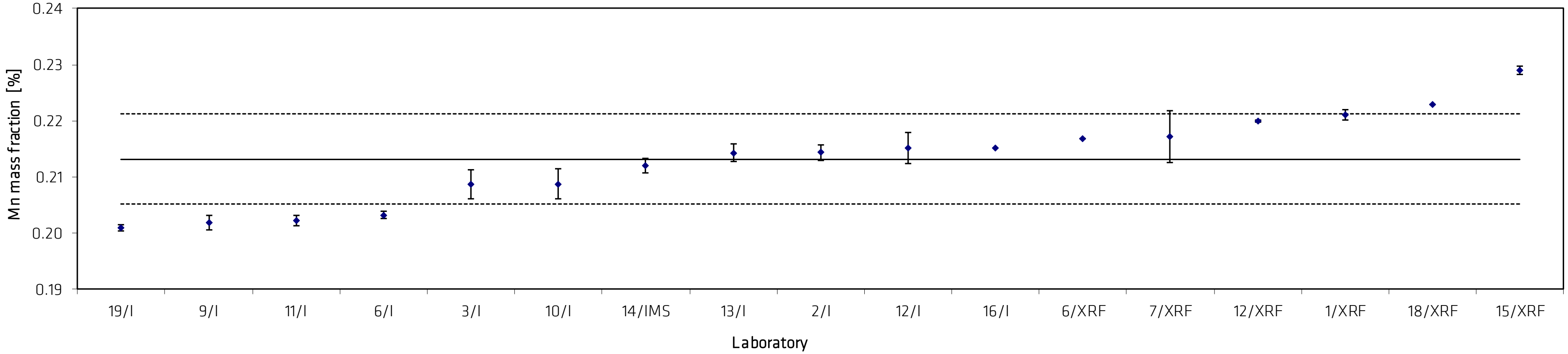


Table 10: Results for Si

Lab./Meth.	19/XRF	4/G	13/I	9/XRF	1/XRF	10/XRF	18/XRF	16/XRF	2/XRF	12/XRF	14/XRF	15/XRF	6/XRF	3/XRF		
M_i [%]	32.83	33.01	32.99	33.0	33.05	33.05	33.1	33.14	33.14	33.18	33.22	33.20	33.27	33.35		*n*
	32.84	32.92	32.96		33.05	33.04	33.1	33.12	33.14	33.17	33.14	33.20	33.16	33.35		14
	32.89	32.85	33.02		33.04	33.04	33.1	33.12	33.14	33.17	33.17	33.20	33.33	33.34		
	32.77		32.92			33.05	33.1	33.10	33.14	33.18	33.17	33.21	33.30	33.36		
M [%]	**32.83**	**32.93**	**32.97**	**33.00**	**33.05**	**33.05**	**33.10**	**33.12**	**33.14**	**33.17**	**33.18**	**33.20**	**33.26**	**33.35**		**33.10**
s [%]	0.049	0.080	0.044		0.006	0.004	0.000	0.015	0.000	0.005	0.033	0.005	0.074	0.006	s_M [%]	0.138
															$\bar{s}_i$ [%]	0.036
s_{rel}	0.00151	0.00244	0.00132		0.00017	0.00013	0.00000	0.00047	0.00000	0.00016	0.00100	0.00015	0.00221	0.00018		0.00416

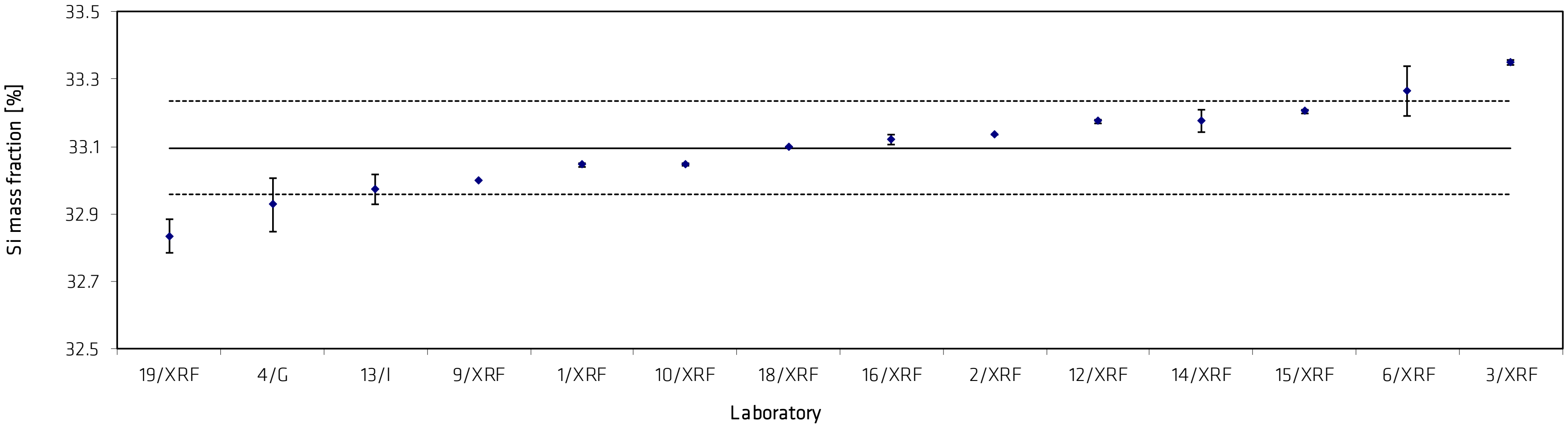


Table 11: Results for As

Lab./Meth.	14/IMS	6/I	13/I	12/XRF	11/I	3/IMS	10/I	7/LA-MS	16/IMS	12/I	15/XRF	9/IMS		
M_i [mg/kg]	4.17	4.5	7.57	6.82	7.70	9.51	9.98	9.86	10.50	10.88	11.00	13.47		*n*
	4.06	5.0	7.57	3.79	7.90	8.28	10.82	9.85	10.11	10.24	17.00	14.95		12
	4.43	4.7	6.06	9.09	8.10	9.07	9.64	10.10	9.80	10.52	9.00	14.64		
	4.73	4.4	7.57	10.60	8.70	8.91	7.71	9.74	9.53	10.82	12.00			
M [mg/kg]	**4.35**	**4.64**	**7.20**	**7.58**	**8.10**	**8.94**	**9.54**	**9.89**	**9.99**	**10.61**	**12.25**	**14.35**		**8.95**
s [mg/kg]	0.30	0.29	0.76	2.96	0.43	0.51	1.31	0.15	0.42	0.29	3.40	0.78	s_M [mg/kg]	2.87
													$\bar{s}_i$ [mg/kg]	1.42
s_{rel}	0.0687	0.0622	0.1053	0.3912	0.0533	0.0570	0.1376	0.0152	0.0420	0.0277	0.2778	0.0542		0.3205

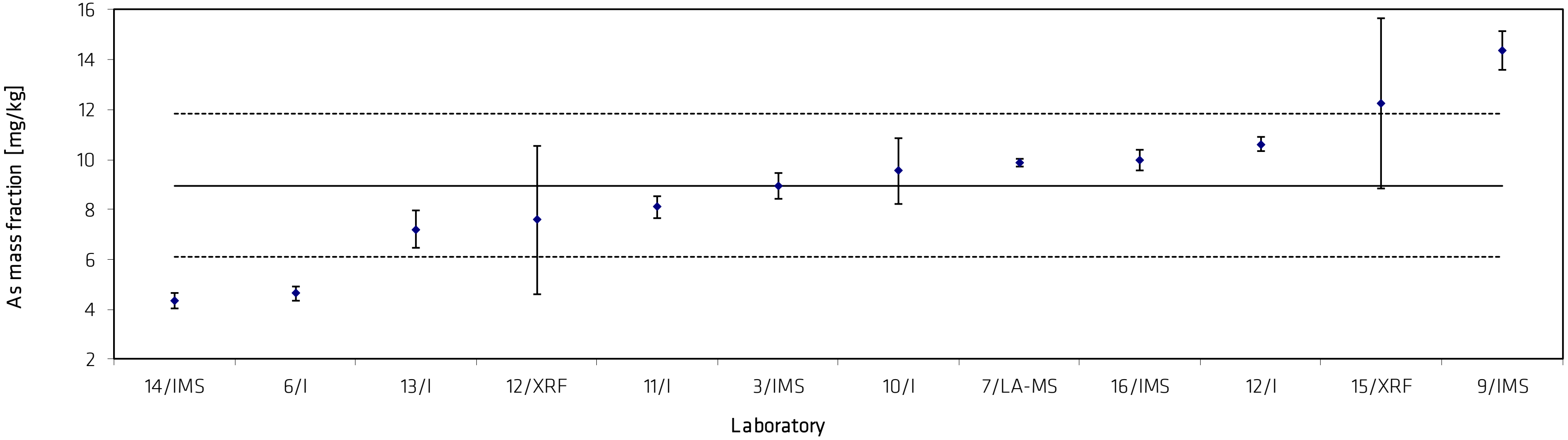


Table 12: Results for Ba

Lab./Meth.	11/I	19/XRF	18/XRF	13/I	6/XRF	10/XRF	12/XRF	1/XRF	15/XRF	14/XRF	17/XRF	7/XRF		
M_i [mg/kg]	397.9	340.3	400	437	465.7	459	468	470	460.0	458.9	476	516.8		n
	393.4	456.8	400	442	456.8	460	471	470	472.0	484.9	474	524.9		12
	397.5	429.9	400	441	447.8	450	475	470	477.0	475.8	474	555.3		
	387.2	403.0	500	463	429.9	443	441		478.0	476.0	486	555.3		
					465.7									
					438.9									
M [mg/kg]	**394.0**	**407.5**	**425.0**	**445.8**	**450.8**	**453.0**	**463.5**	**470.0**	**471.8**	**473.9**	**477.4**	**538.1**		**455.9**
s [mg/kg]	5.0	49.9	50.0	11.7	14.6	8.0	15.5	0.0	8.3	10.9	5.7	20.2	s_M [mg/kg]	37.3
													$\bar{s}_i$ [mg/kg]	22.9
s_{rel}	0.0127	0.1224	0.1176	0.0263	0.0324	0.0177	0.0335	0.0000	0.0175	0.0229	0.0120	0.0375		0.0818

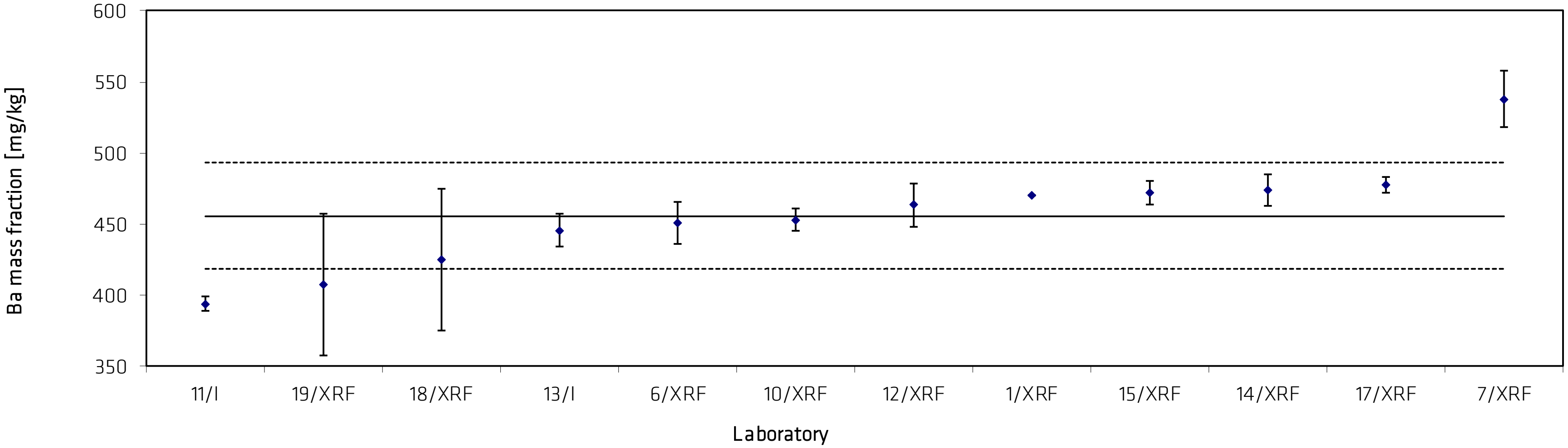


Table 13: Results for Cd

Lab./Meth.	3/IMS	14/IMS	11/I	7/LA-MS	11/EA	19/I	12/I	13/I	6/I	9/IMS	16/IMS	10/I	12/XRF		
M_i [mg/kg]	0.11	0.13	0.20	0.24	0.26	0.30	0.30	0.40	1.00	<1	<1	<2	<2		n
	0.11	0.12	0.20	0.20	0.24	0.30	0.28	0.40	0.99	<1	<1	<2	<2		9
	0.12	0.13	0.20	0.22	0.24	0.20	0.31	0.40	0.96	<1	<1	<2	<2		
	0.12	0.13	0.20	0.26	0.25	0.20	0.29	0.70	0.97		<1	<2	<2		
					0.24										
M [mg/kg]	**0.11**	**0.13**	**0.20**	**0.23**	**0.25**	**0.25**	**0.29**	**0.48**	**0.98**	**<1**	**<1**	**<2**	**<2**		**0.21**
s [mg/kg]	0.006	0.004	0.000	0.025	0.009	0.058	0.012	0.150	0.018					s_M [mg/kg]	0.067
														$\bar{s}_i$ [mg/kg]	0.025
s_{rel}	0.0554	0.0280	0.0000	0.1065	0.0375	0.2309	0.0419	0.3158	0.0186						0.3232

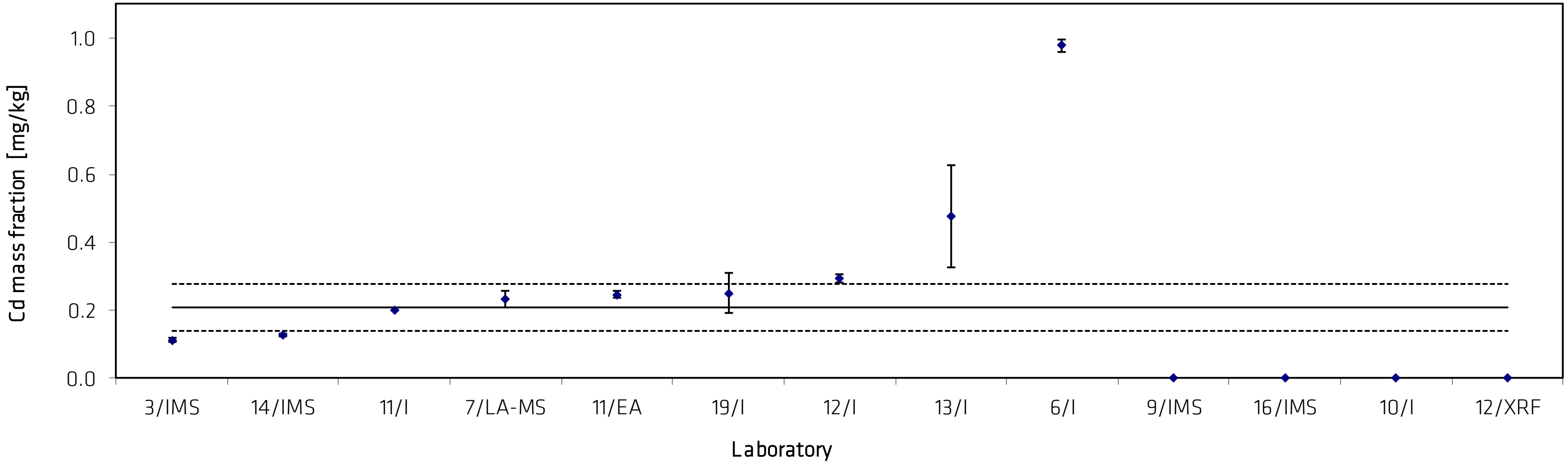


Table 14: Results for Co

Lab./Meth.	3/I	6/I	14/IMS(R)	12/XRF	12/I	19/I	18/XRF	13/I	11/I	7/LA-MS	15/XRF	9/I	2/I	10/I	16/IMS		
M_i [mg/kg]	127	160.1	159	164.4	166.1	169	170	173.2	175.7	177.5	179	178.8	180	177.2	180.4		*n*
	125	157.0	161	162.0	165.9	169	170	174.7	175.1	177.2	177	180.2	179	180.9	179.1		15
	131	157.2	163	161.2	167.2	170	170	169.1	172.2	177.3	180	179.3	180	182.1	184.3		
	128	153.7	163	165.2	167.9	170	170	169.5	172.1	177.5	177		180	179.2	177.9		
M [mg/kg]	**127.7**	**157.0**	**161.5**	**163.2**	**166.8**	**169.2**	**170.0**	**171.6**	**173.8**	**177.4**	**178.3**	**179.4**	**179.8**	**179.9**	**180.4**		**172.0**
s [mg/kg]	2.26	2.60	1.89	1.87	0.94	0.70	0.00	2.77	1.89	0.14	1.50	0.71	0.50	2.15	2.78	s_M [mg/kg]	7.70
																$\bar{s}_i$ [mg/kg]	1.73
s_{rel}	0.0177	0.0165	0.0117	0.0115	0.0057	0.0042	0.0000	0.0161	0.0109	0.0008	0.0084	0.0040	0.0028	0.0120	0.0154		0.0448

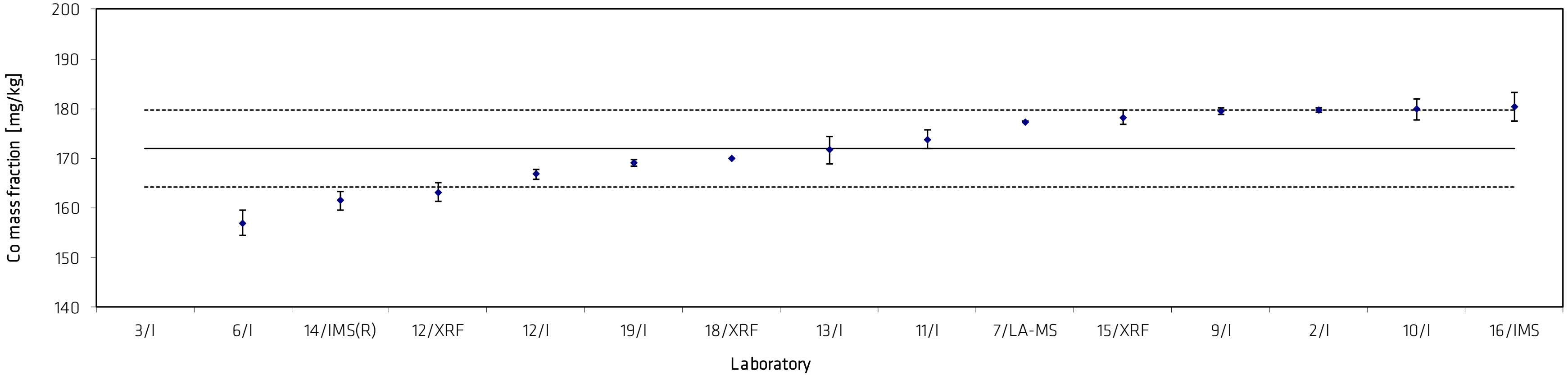


Table 15: Results for Ni

Lab./Meth.	9/IMS	12/I	16/IMS	18/I	13/I	7/LA-MS	2/I	10/I	19/I	14/IMS(R)	12/XRF	15/XRF	11/I	3/I	1/XRF		
M_i [mg/kg]	14.62	16.41	17.18	17	18.2	17.82	18.4	17.65	18.6	20.67	20.43	21	22.0	22.6	25.1		n
	15.85	16.47	17.44	18	18.5	17.92	17.9	18.10	17.9	20.27	22.00	21	22.0	21.5	24.4		15
	15.26	17.00	17.41	17	17.9	17.76	18.0	18.16	20.3	19.81	20.43	22	22.0	21.7	23.6		
		16.69	17.83	18	16.3	17.66	17.7	18.62	18.9	21.15	23.57	23	21.0	21.8			
M [mg/kg]	**15.24**	**16.64**	**17.46**	**17.50**	**17.72**	**17.79**	**18.00**	**18.13**	**18.93**	**20.48**	**21.61**	**21.75**	**21.75**	**21.90**	**24.36**		**19.28**
s [mg/kg]	0.61	0.27	0.27	0.58	0.99	0.11	0.29	0.40	1.01	0.57	1.50	0.96	0.50	0.49	0.79	s_M [mg/kg]	2.52
																$\bar{s}_i$ [mg/kg]	0.72
s_{rel}	0.0402	0.0160	0.0154	0.0330	0.0562	0.0064	0.0164	0.0220	0.0533	0.0279	0.0696	0.0440	0.0230	0.0225	0.0323		0.1309

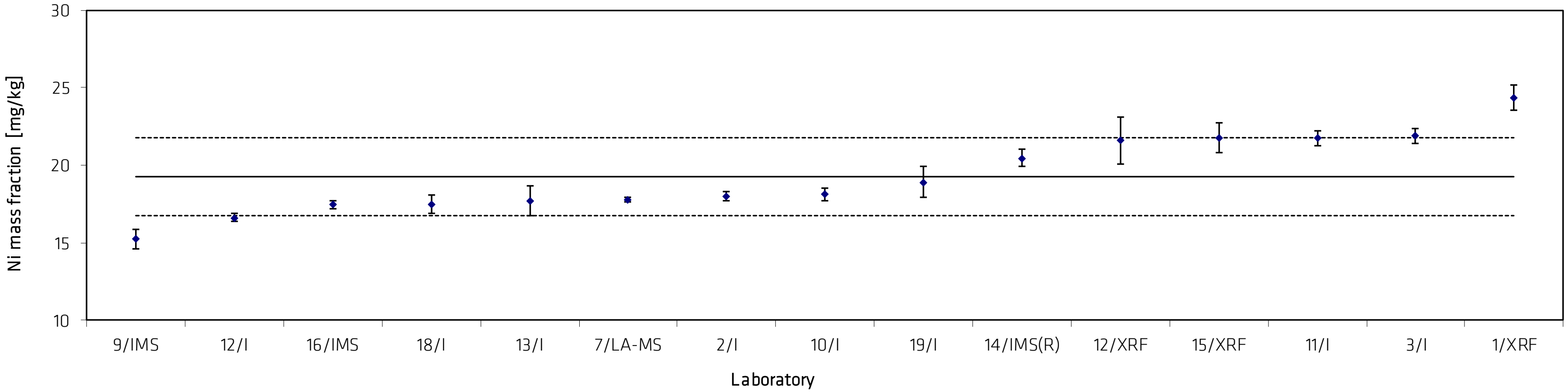


Table 16: Results for P

Lab./Meth.	7/XRF	11/I	14/XRF	12/XRF	18/XRF	19/XRF	17/XRF		
M_i [mg/kg]	74	74.8	87.3	84.2	90	82.9	91.0		*n*
		81.3	82.9	83.8	100	87.3	93.0		7
		75.8	82.9	86.4	80	109.1	94.5		
		74.0	84.0	86.4	90	87.3	95.4		
M [mg/kg]	**74.0**	**76.5**	**84.3**	**85.2**	**90.0**	**91.7**	**93.5**		**85.0**
s [mg/kg]		3.3	2.1	1.4	8.2	11.8	1.9	s_M [mg/kg]	7.5
								$\bar{s}_i$ [mg/kg]	5.7
s_{rel}		0.0433	0.0247	0.0164	0.0907	0.1289	0.0205		0.0878

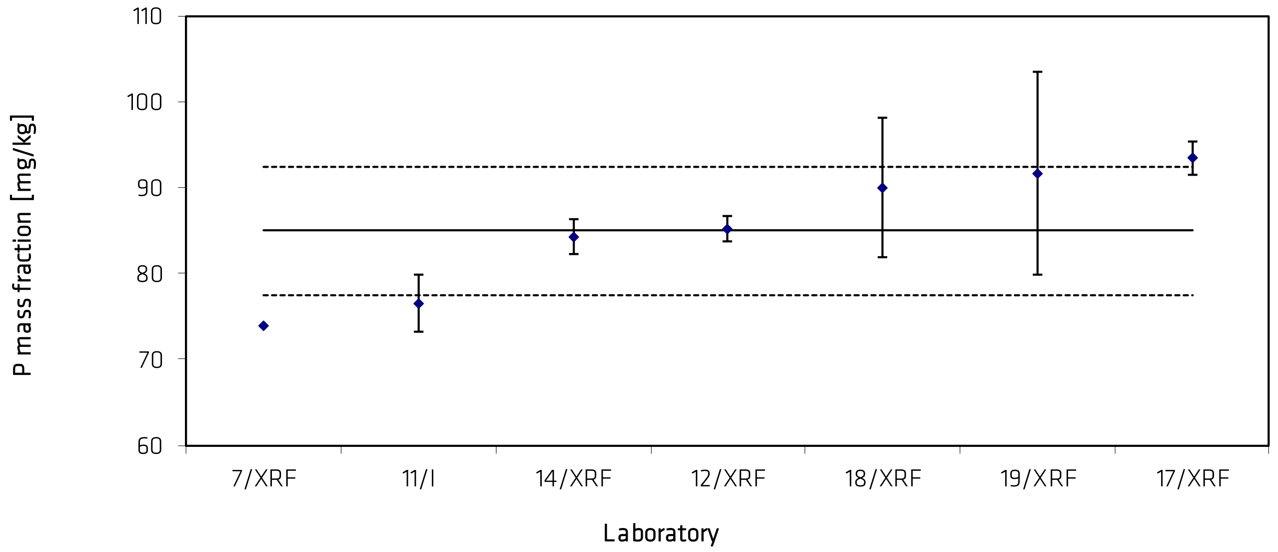


Table 17: Results for Pb

Lab./Meth.	17/XRF(R)	7/LA-MS	12/I	14/I	10/XRF	6/I	7/XRF	12/XRF	18/I	10/I	16/IMS	15/XRF	13/I	9/I	11/I	3/I	19/I	1/XRF		
M_i [mg/kg]	90.1	91.2	93.6	91.0	92.8	94.6	97.5	104.9	103	104.8	109.2	107	110.8	108.8	112.0	110.9	117.3	116		n
	90.1	93.3	91.8	93.0	92.8	95.6	97.5	101.2	104	107.4	108.8	108	110.8	112.2	109.0	106.8	115.7	124		18
	89.6	91.3	91.3	94.0	98.4	97.1	100.9	101.2	103	107.3	108.9	109	108.6	107.8	110.0	113.0	113.1	121		
	90.1	90.3	94.4	96.0	94.7	94.3	100.4	104.0	104	104.8	105.5	109	107.9		110.0	115.8	112.5			
M [mg/kg]	**90.0**	**91.5**	**92.8**	**93.5**	**94.7**	**95.4**	**99.1**	**102.8**	**103.5**	**106.0**	**108.1**	**108.3**	**109.5**	**109.6**	**110.3**	**111.6**	**114.7**	**120.3**		**103.4**
s [mg/kg]	0.3	1.3	1.5	2.1	2.6	1.2	1.8	1.9	0.6	1.5	1.7	1.0	1.5	2.3	1.3	3.8	2.2	4.0	s_M [mg/kg]	8.9
																			$\bar{s}_i$ [mg/kg]	2.0
s_{rel}	0.00278	0.01401	0.01606	0.02226	0.02773	0.01294	0.01854	0.01859	0.00558	0.01410	0.01604	0.00884	0.01350	0.02131	0.01141	0.03407	0.01960	0.03359		0.08605

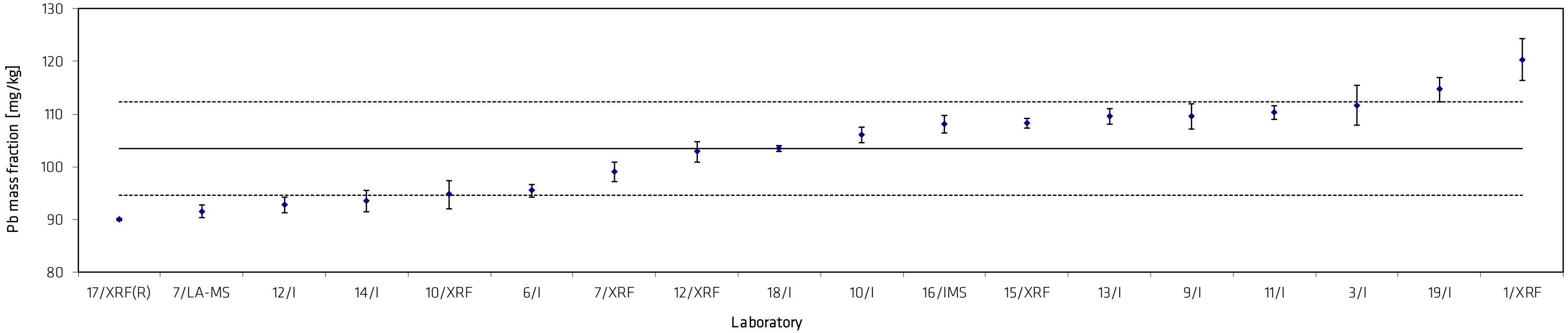


Table 18: Results for S

Lab./Meth.	12/XRF	2/Comb.	7/XRF	11/Comb.	19/XRF	13/I	15/XRF	14/XRF	17/XRF	1/XRF		
M_i [mg/kg]	182 181 183 181	185.5 187.9 181.2 184.3	194.6 193.0 199.8 199.0	203.5 203.8 194.2 198.9	188.2 200.2 176.2 236.3	201 211 197 212	211 203 206 210	209 214 217 217	220 218 218 218	270 280 280		*n* 10
M [mg/kg]	181.4	184.7	196.6	200.1	200.2	205.3	207.5	214.4	218.8	276.7		201.0
s [mg/kg]	1.0	2.8	3.3	4.5	26.0	7.4	3.7	3.7	1.0	5.8	s_M [mg/kg] $\bar{s}_i$ [mg/kg]	12.4 9.4
s_{rel}	0.0054	0.0151	0.0169	0.0227	0.1297	0.0361	0.0178	0.0172	0.0046	0.0209		0.0615

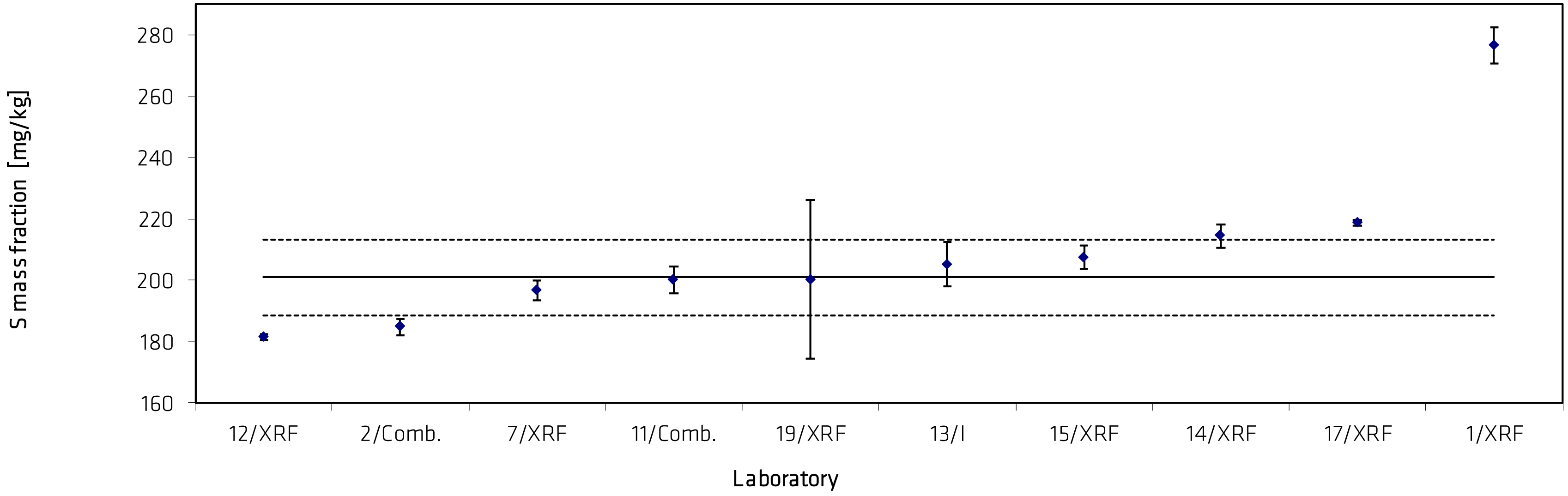


Table 19: Results for Sb

Lab./Meth.	12/XRF	17/XRF	10/I	12/I	3/IMS	11/I	9/IMS	13/I	14/IMS	7/LA-MS	16/IMS		
M_i [mg/kg]	8.4	10.0	9.0	10.1	10.4	10.0	11.9	15.0	14.46	13.9	14.4		*n*
	7.5	9.2	9.0	8.9	10.4	10.1	13.1	11.7	13.54	14.0	14.2		11
	5.0	5.9	8.8	10.8	10.7	10.6	12.4	9.2	13.11	14.2	14.6		
	7.5	7.1	8.2	9.9	9.8	10.6		14.2	14.48	14.6	14.4		
M [mg/kg]	**7.1**	**8.0**	**8.8**	**9.9**	**10.3**	**10.3**	**12.5**	**12.5**	**13.9**	**14.2**	**14.4**		**10.8**
s [mg/kg]	1.45	1.90	0.37	0.80	0.39	0.32	0.57	2.64	0.68	0.28	0.14	s_M [mg/kg]	2.44
												$\bar{s}_i$ [mg/kg]	1.15
s_{rel}	0.2038	0.2361	0.0423	0.0803	0.0375	0.0310	0.0460	0.2108	0.0492	0.0200	0.0099		0.2265

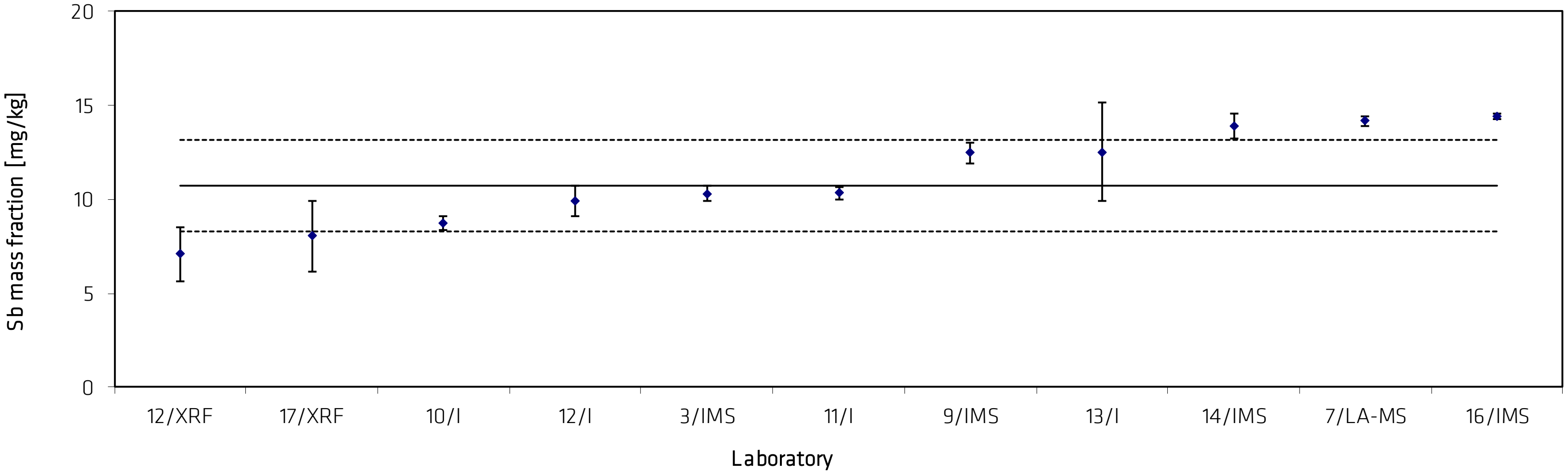


Table 20: Results for Sr

Lab./Meth.	15/XRF	19/XRF	7/XRF	12/XRF	18/XRF	13/I	1/XRF		
M_i [mg/kg]	122.0	124.3	125.1	128	130	144	140		*n*
	122.0	126.0	125.1	128	130	136	140		7
	122.0	119.2		127	130	139	140		
	121.0	121.8		126	130	139			
M [mg/kg]	**121.8**	**122.8**	**125.1**	**127.1**	**130.0**	**139.5**	**140.0**		**129.5**
s [mg/kg]	0.50	2.97	0.00	0.81	0.00	3.32	0.00	s_M [mg/kg]	7.53
								$\bar{s}_i$ [mg/kg]	1.72
s_{rel}	0.00411	0.02417	0.00000	0.00637	0.00000	0.02378	0.00000		0.05815

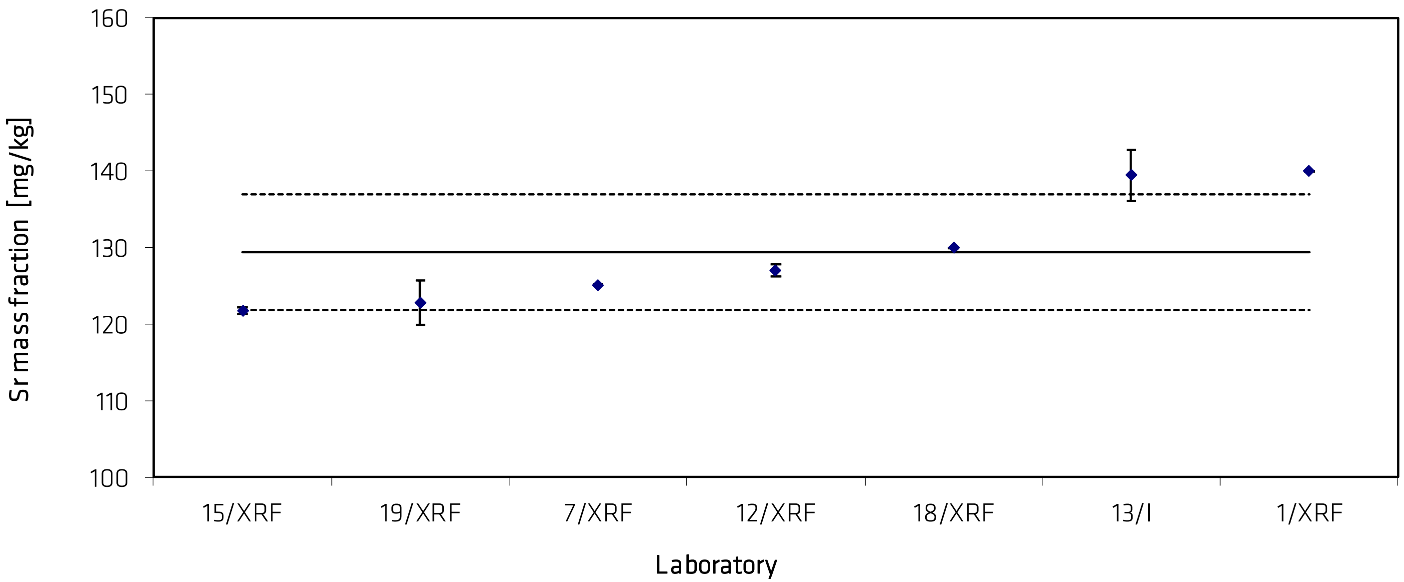


Table 21: Results for Ti

Lab./Meth.	13/I	15/XRF	12/XRF	6/XRF	14/XRF	10/XRF	18/XRF	7/XRF	1/XRF		
M_i [mg/kg]	362	386.0	390	390	392	402	370	401.1	400		*n*
	381	381.0	387	390	397	390	390	401.1	400		9
	370	385.0	393	396	391	389	410	393.9	400		
	378	377.0	381	408	397	400	410	391.5			
				396							
				384							
M [mg/kg]	372.8	382.3	387.5	393.6	393.9	395.0	395.0	396.9	400.0		390.8
s [mg/kg]	8.5	4.1	4.9	8.2	3.3	6.8	19.1	4.9	0.0	s_M [mg/kg]	8.5
										$\bar{s}_i$ [mg/kg]	8.4
s_{rel}	0.0229	0.0108	0.0125	0.0208	0.0084	0.0173	0.0485	0.0125	0.0000		0.0219

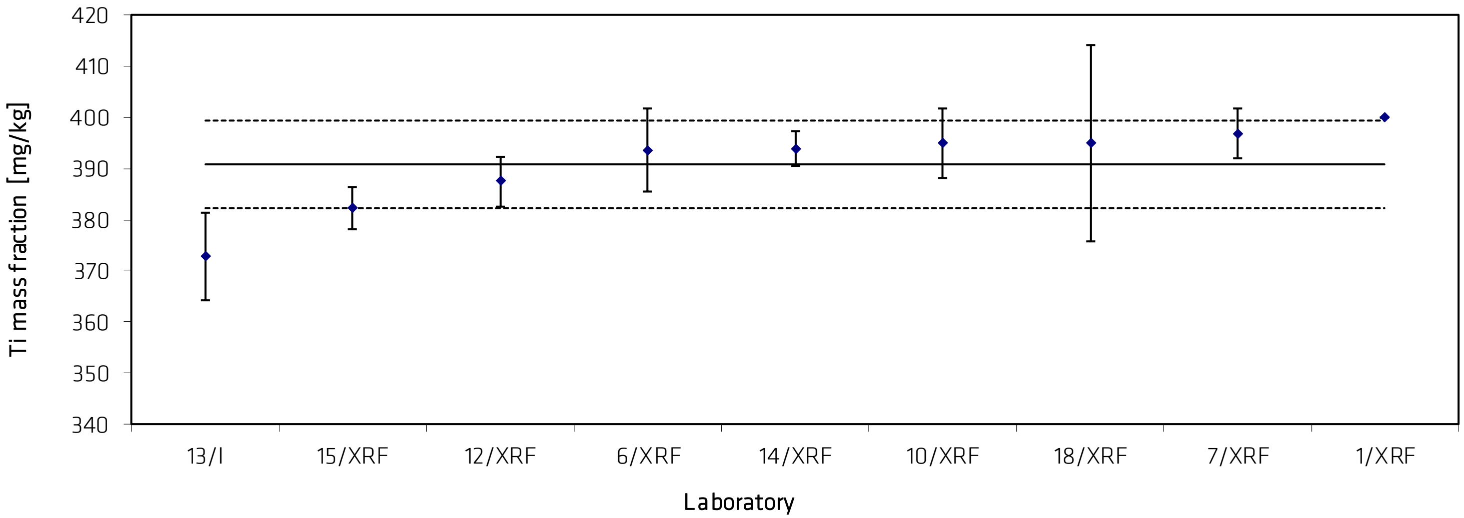


Table 22: Results for Zr

Lab./Meth.	18/XRF	10/XRF	7/XRF	14/XRF	12/XRF	15/XRF	11/I	17/XRF	19/XRF		
M_i [mg/kg]	130	133.0	124.4	136.9	138.4	144.0	153.3	184.3	192.5		*n*
	130	133.0	124.4	137.3	136.2	144.0	164.3	183.6	213.9		9
	130	133.3	140.7	138.0	144.4	143.0	159.6	184.0	224.3		
	130	134.7	146.6	136.6	146.6	144.0	138.7	183.6	192.5		
M [mg/kg]	**130.0**	**133.5**	**134.0**	**137.2**	**141.4**	**143.8**	**154.0**	**183.9**	**205.8**		**139.1**
s [mg/kg]	0.0	0.8	11.4	0.6	4.9	0.5	11.1	0.4	15.9	s_M [mg/kg]	8.1
										$\bar{s}_i$ [mg/kg]	6.3
s_{rel}	0.0000	0.0061	0.0849	0.0044	0.0345	0.0035	0.0722	0.0019	0.0774		0.0581

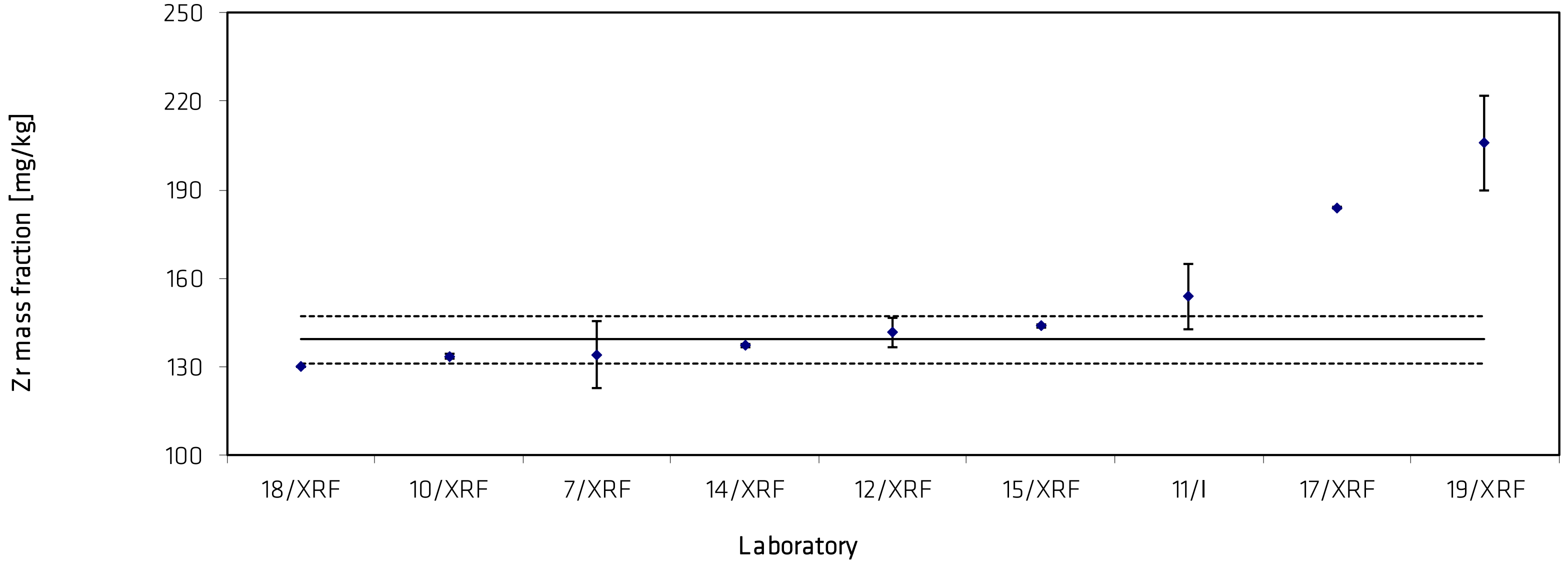


Table 23: Results for Cl

Lab./Meth.	12/XRF	7/XRF	15/XRF	19/XRF	14/XRF	17/XRF		
M_i [mg/kg]	140	124	179	200	260	359		*n*
	156	188	169	200	200	338		6
	155		168	190	210	318		
	162		158	210	220	289		
M [mg/kg]	**153.3**	**156.0**	**168.5**	**200.0**	**222.5**	**325.8**		**180.1**
s [mg/kg]	9.36	45.25	8.58	8.16	26.30	30.06	s_M [mg/kg]	30.1
							$\bar{s}_i$ [mg/kg]	24.4
s_{rel}	0.0611	0.2901	0.0509	0.0408	0.1182	0.0923		0.1673

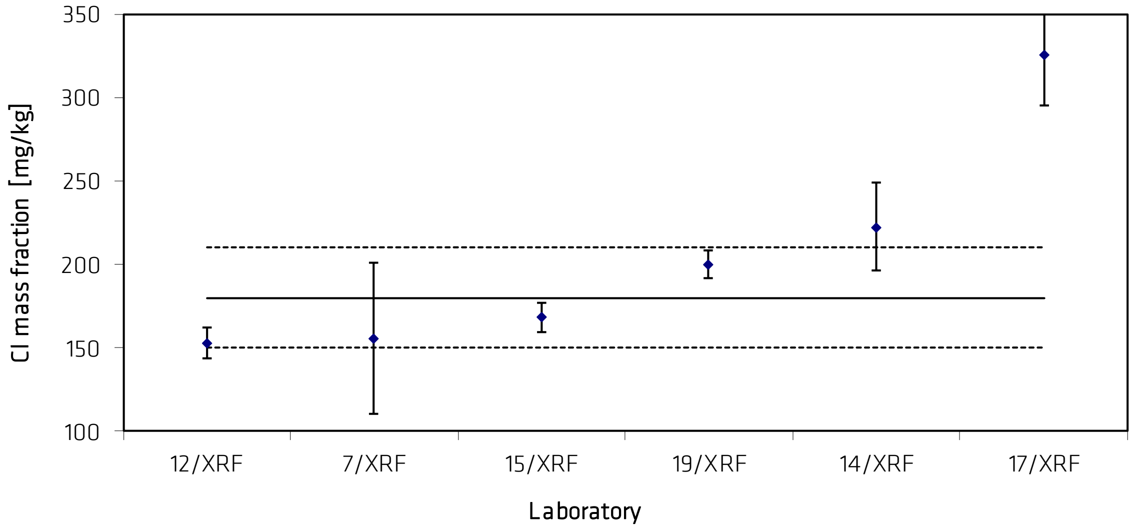


Table 24: Results for Cu

Lab./Meth.	17/XRF	12/XRF	18/XRF	15/XRF	14/XRF		
M_i [mg/kg]	10.8	20.8	30.0	27.0	47.9		*n*
	11.6	22.4	20.0	27.0	32.0		5
	12.0	20.8	20.0	27.0	40.0		
	11.2	24.0	30.0	28.0	47.9		
M [mg/kg]	11.4	22.0	25.0	27.3	42.0		25.5
s [mg/kg]	0.52	1.53	5.77	0.50	7.61	s_M [mg/kg]	11.0
						$\bar{s}_i$ [mg/kg]	4.3
s_{rel}	0.0453	0.0696	0.2309	0.0183	0.1813		0.4319

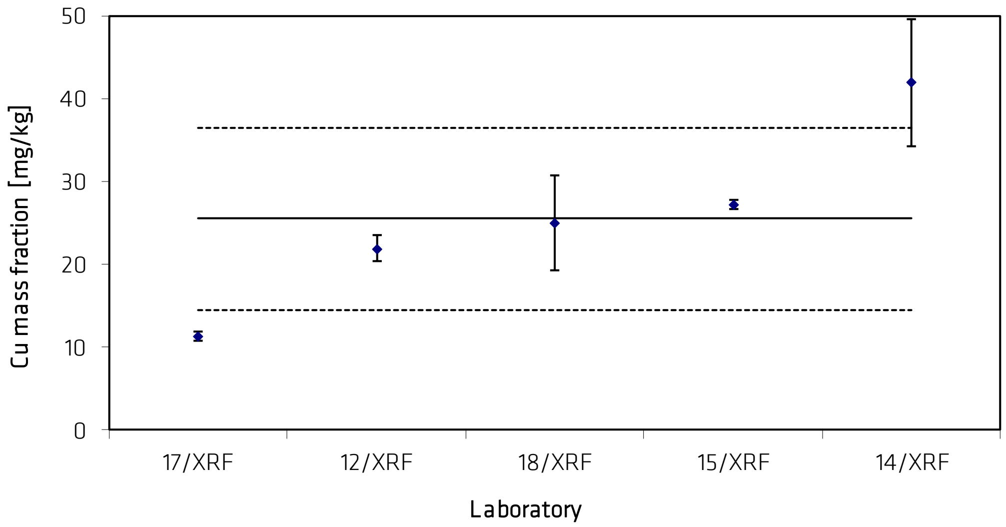
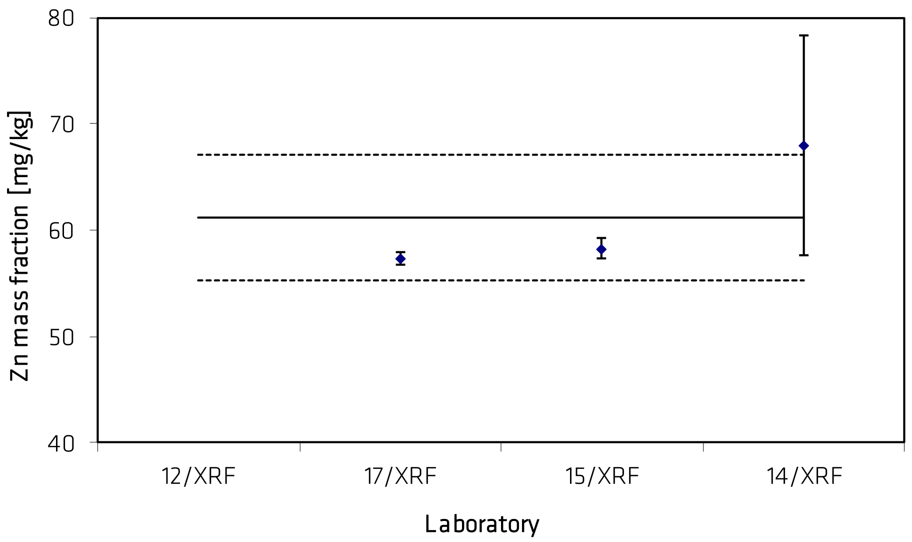


Table 25: Results for Zn

Lab./Meth.	12/XRF	17/XRF	15/XRF	14/XRF		
M_i [mg/kg]	18.5	56.6	59.0	64.0		*n*
	17.7	57.0	57.0	56.0		4
	17.7	57.8	59.0	72.0		
	20.1	57.8	58.0	80.0		
M [mg/kg]	**18.5**	**57.3**	**58.3**	**68.0**		**61.2**
s [mg/kg]	1.14	0.60	0.96	10.33	s_M [mg/kg]	5.91
					$\bar{s}_i$ [mg/kg]	5.23
s_{rel}	0.0615	0.0105	0.0164	0.1519		0.0965



The statistical evaluation of the data was performed using the software program BAM-ecerto [5]. The Cochran-test was only performed once. The following results were obtained:

Tab. 26: Outcome of statistical tests on the results obtained for Al and Mg

	Al	Mg
Number of data sets	18	18
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	Lab. 6	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	Lab. 6	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	Lab. 12	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers were not removed.

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

	1st run	2nd run
Number of data sets	16	14
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	Labs. 6 and 1	---
Grubbs Pair (α = 0.01)	Labs. 6 and 1	---
Cochran (α = 0.01)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers were removed.

Tab. 28: Outcome of statistical tests on the results obtained for Fe and K

	Fe	K
Number of data sets	18	21
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	Labs. 3 and 4	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	Lab. 7	Lab. 7
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers were not removed.

Tab. 29: Outcome of statistical tests on the results obtained for Na

	1st run	2nd run
Number of data sets	19	18
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	Lab. 19	---
Dixon (α = 0.01)	Lab. 19	---
Grubbs (α = 0.05)	Lab. 19	---
Grubbs (α = 0.01)	Lab. 19	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	Lab. 11	Lab. 11
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier (Lab. 19, 1st run) was removed.

Tab. 30: Outcome of statistical tests on the results obtained for Si and Mn

	Si	Mn
Number of data sets	14	17
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier was not removed.

Tab. 31: Outcome of statistical tests on the results obtained for As and Ni

	As	Ni
Number of data sets	12	15
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	Lab. 15	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier was not removed.

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

	Ba
Number of data sets	12
Scheffe's test (data compatible?)	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed
Dixon (α = 0.05)	---
Dixon (α = 0.01)	---
Grubbs (α = 0.05)	---
Grubbs (α = 0.01)	---
Grubbs Pair (α = 0.05)	---
Grubbs Pair (α = 0.01)	---
Cochran (α = 0.01)	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal

Tab. 33: Outcome of statistical tests on the results obtained for Cr

	1st run	2nd run
Number of data sets	20	18
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	Lab. 13
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	---	Lab. 13
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	Labs. 7/X and 7/LA	---
Grubbs Pair (α = 0.01)	Labs. 7/X and 7/LA	---
Cochran (α = 0.01)	Lab. 3	Lab. 3
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The Grubbs outliers (1st run) were removed.

Tab. 34: Outcome of statistical tests on the results obtained for Cd

	1st run	2nd run
Number of data sets	9	7
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	Lab. 6	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	Lab. 6	---
Grubbs (α = 0.01)	Lab. 6	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	Lab. 13	Lab. 19
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers (Lab. 6, Lab. 13) were removed.

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

	1st run	2nd run
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 (α = 0.05)	Lab. 3	---
Dixon (α = 0.01)	Lab. 3	---
Grubbs (α = 0.05)	Lab. 3	---
Grubbs (α = 0.01)	Lab. 3	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier (Lab. 3) was removed.

Tab. 36: Outcome of statistical tests on the results obtained for P and Pb

	P	Pb
Number of data sets	7	18
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier was not removed.

Tab. 37: Outcome of statistical tests on the results obtained for Sb and Sr

	Sb	Sr
Number of data sets	11	7
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	Lab. 13	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: not normal	Distribution: normal

The outlier was not removed.

Tab. 38: Outcome of statistical tests on the results obtained for S

	1st run	2nd run
Number of data sets	10	9
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	Lab. 1	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	Lab. 1	---
Grubbs (α = 0.01)	Lab. 1	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	Lab. 19	Lab. 19
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier (Lab. 1) was removed.

Tab. 39: Outcome of statistical tests on the results obtained for Ti and Cu

	Ti	Cu
Number of data sets	9	5
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	Lab. 18	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outliers were not removed.

Tab. 40: Outcome of statistical tests on the results obtained for Cl

	1st run	2nd run
Number of data sets	6	5
Scheffe's test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	Lab. 17	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	Lab. 17	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The outlier (Lab. 17) was removed.

Tab. 41: Outcome of statistical tests on the results obtained for Zr

	1st run	2nd run
Number of data sets	9	7
Scheffe’s test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	---	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	---	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	Labs. 17 and 19	---
Grubbs Pair (α = 0.01)	Labs. 17 and 19	---
Cochran (α = 0.01)	---	---
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The Grubbs outliers were removed.

Tab. 42: Outcome of statistical tests on the results obtained for Zn

	1st run	2nd run
Number of data sets	4	3
Scheffe’s test (data compatible?)	yes	yes
Snedecor-F-Test and Bartlett-Test	Pooling not allowed	Pooling not allowed
Dixon (α = 0.05)	Lab. 12	---
Dixon (α = 0.01)	---	---
Grubbs (α = 0.05)	Lab. 12	---
Grubbs (α = 0.01)	---	---
Grubbs Pair (α = 0.05)	---	---
Grubbs Pair (α = 0.01)	---	---
Cochran (α = 0.01)	Lab. 14	Lab. 14
Kolmogorov-Smirnov-Lilliefors Test	Distribution: normal	Distribution: normal

The Grubbs outlier was removed.

The certified mass fractions of all elements were calculated as mean of the accepted data sets. These values are given in Table 43. The mass fractions of P, Cl, Cu, Sr, and Zn are given for information only because there were not enough data sets, or the distribution of an element was not sufficiently homogeneous (Sr). These elements are also mentioned in the certificate.
The resp. combined uncertainties were calculated from the spread resulting from the certification inter-laboratory comparison (u_{ilc}) and the uncertainty contribution from possible inhomogeneity between the different discs (u_{bb}) of the material using Equation 3.

$$u_c = \sqrt{u_{ilc}^2 + u_{bb}^2} \qquad (3)$$

with

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

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

Table 43: Uncertainty calculation

		uncertainty contribution from							
	M	n	s_M	u_{ilc}	u_{bb}*	$u_{combined}$	U		u_{bb} (rel)
	%		%	%	%	%	%		
Al	1.08	18	0.0213	0.0050	0.0051	0.0071	0.0143		0.4704
Ca	7.66	14	0.0259	0.0069	0.0030	0.0075	0.0151		0.0392
Mg	1.16	18	0.0155	0.0037	0.0032	0.0048	0.0097		0.2736
Na	8.79	18	0.0684	0.0161	0.0502	0.0528	0.1055		0.5713
K	0.577	21	0.0181	0.0040	0.0007	0.0040	0.0080		0.1157
Fe	0.468	18	0.0160	0.0038	0.0006	0.0038	0.0076		0.1252
Cr	0.382	18	0.0117	0.0028	0.0002	0.0028	0.0055		0.0577
Mn	0.213	17	0.0080	0.0019	0.0001	0.0019	0.0039		0.0614
Si	33.10	14	0.1380	0.0369	0.0417	0.0557	0.1114		0.1260
	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg		
As	8.95	12	2.87	0.828	0.103	0.8348	1.6696		1.1458
Ba	456	12	37.31	10.769	3.752	11.4042	22.8084		0.8229
Cd	0.21	7	0.07	0.025	0.008	0.0267	0.0534		3.8698
Co	172	14	7.70	2.058	0.344	2.0865	4.1731		0.2002
Ni	19.28	15	2.52	0.651	0.133	0.6641	1.3282		0.6894
P	85.0	7	7.47	2.822	7.366	7.8881	15.7762		8.6658
Pb	103	18	8.90	2.097	0.244	2.1116	4.2233		0.2361
S	201	9	12.37	4.124	1.478	4.3804	8.7608		0.7349
Sb	10.8	11	2.44	0.736	0.050	0.7374	1.4747		0.4611
Sr	130	7	7.53	2.846	40.704	40.8031	81.6061		31.4314
Ti	391	9	8.50	2.833	0.600	2.8961	5.7921		0.1533
Cu	26	5	11.00	4.919	0.124	4.9209	9.8418		0.4855
Cl	180	5	30.12	13.472	1.234	13.5286	27.0573		0.6853
Zn	61	3	5.91	3.411	0.360	3.4298	6.8597		0.5894
Zr	139	7	8.08	3.055	13.152	13.5018	27.0036		9.4617

*calculated from u_{bb}(rel): $u_{bb} = \frac{M \cdot u_{bb}(rel)}{100}$

The expanded uncertainties U are calculated by multiplication of $u_{combined}$ with a coverage factor of k = 2 using Equation 4.

$$U = k \cdot u_{combined} \quad (4)$$

The calculated mass fractions and their resp. expanded uncertainties are given on Page 3 of this report. Rounding was done according to DIN 1333 [6].

6. Instructions for users and stability

The certified reference material BAM-S006 is intended for the calibration and quality control of 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 carefully before analysis.
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 or X-Ray radiation over long time. It should be stored in a dry and clean environment at room temperature.
After multiple measurements with XRF, discolouration of the glass may occur. This can be reversed by heat treatment at 300 - 400 ° C.

7. Metrological Traceability

To ensure traceability of the certified mass fractions to the SI (Système International d'Unités) calibration for most of the data sets was performed using standard solutions prepared from pure metals or stoichiometric compounds or well checked commercial calibration solutions. Some of the datasets are traceable to other certified reference materials or reference materials (e.g. BAM-S005).

8. Information on and purchase of the CRM

Certified reference material BAM-S006 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 or each bottle of BAM-S006 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, 2017

[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] ZGU Ilmenau.: Prüfbericht zum Laborauftrag Nr. 0844/2022

[5] Lisec, J.: BAM ecerto Softwaretool (BAM 2019)

[6] DIN 1333:1992-02 Zahlenangaben

Annex 1: Homogeneity test performed with XRF (ANOVA), mass fractions in %

Aluminium

	1	2	3
Glass 1	2.001	2.003	1.995
Glass 2	1.982	1.969	1.973
Glass 3	1.982	1.983	1.968
Glass 4	1.981	1.982	1.981
Glass 5	1.997	1.995	1.994
Glass 6	1.978	1.976	1.973
Glass 7	1.982	1.980	1.979
Glass 8	1.975	1.972	1.970
Glass 9	1.970	1.973	1.971
Glass 10	1.981	1.977	1.972
Glass 11	1.989	1.991	1.990
Glass 12	1.988	1.990	1.989
Glass 13	1.983	1.972	1.973
Glass 14	1.988	1.987	1.985
Glass 15	1.992	1.993	1.994
Glass 16	1.994	1.989	1.987
Glass 17	1.973	1.967	1.968
Glass 18	1.988	1.988	1.987
Glass 19	1.998	1.992	1.991
Glass 20	1.967	1.964	1.973

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	0.005210811	19	0.000274253	20.567621	5.824E-15	1.8528918
Within groups	0.000533369	40	1.33342E-05			
Total	0.00574418	59				
within-sd	0.00365					
effective n	3.00					
s_bb	0.009325932					
s_bb_min	0.00100					
u_bb	0.00933					
u_bb(rel.)	0.47042					

Arsenic

	1	2	3
Glass 1	0.00376	0.00406	0.00411
Glass 2	0.00395	0.00412	0.00421
Glass 3	0.00400	0.00394	0.00413
Glass 4	0.00406	0.00367	0.00399
Glass 5	0.00380	0.00405	0.00380
Glass 6	0.00424	0.00386	0.00376
Glass 7	0.00410	0.00406	0.00412
Glass 8	0.00411	0.00379	0.00391
Glass 9	0.00408	0.00407	0.00376
Glass 10	0.00377	0.00420	0.00402
Glass 11	0.00379	0.00392	0.00420
Glass 12	0.00413	0.00388	0.00418
Glass 13	0.00417	0.00444	0.00408
Glass 14	0.00427	0.00417	0.00406
Glass 15	0.00411	0.00401	0.00391
Glass 16	0.00395	0.00381	0.00388
Glass 17	0.00403	0.00393	0.00400
Glass 18	0.00418	0.00367	0.00415
Glass 19	0.00415	0.00424	0.00440
Glass 20	0.00394	0.00374	0.00414

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	6.47414E-07	19	3.40744E-08	1.198948	0.3057224	1.8528918
Within groups	1.13681E-06	40	2.84203E-08			
Total	1.78423E-06	59				
within-sd	0.00017					
effective n	3.00					
s_bb	4.34134E-05					
s_bb_min	0.00005					
u_bb	0.00005					
u_bb(rel.)	1.14584					

Barium

	1	2	3
Glass 1	0.04407	0.04658	0.04636
Glass 2	0.04635	0.04388	0.04709
Glass 3	0.04631	0.04578	0.04643
Glass 4	0.04367	0.04700	0.04361
Glass 5	0.04521	0.04487	0.04513
Glass 6	0.04480	0.04722	0.04340
Glass 7	0.04370	0.04715	0.04607
Glass 8	0.04644	0.04320	0.04373
Glass 9	0.04602	0.04390	0.04287
Glass 10	0.04593	0.04321	0.04514
Glass 11	0.04547	0.04506	0.04483
Glass 12	0.04443	0.04592	0.04453
Glass 13	0.04785	0.04518	0.04491
Glass 14	0.04603	0.04566	0.04592
Glass 15	0.04460	0.04521	0.04577
Glass 16	0.04400	0.04345	0.04553
Glass 17	0.04533	0.04424	0.04635
Glass 18	0.04324	0.04640	0.04820
Glass 19	0.04506	0.04484	0.04550
Glass 20	0.04511	0.04738	0.04524

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.91602E-05	19	1.00843E-06	0.5415692	0.9240114	1.8528918
Within groups	7.44823E-05	40	1.86206E-06			
Total	9.36425E-05	59				
within-sd	0.00136					
effective n	3.00					
s_bb	0					
s_bb_min	0.00037					
u_bb	0.00037					
u_bb(rel.)	0.82290					

Calcium

	1	2	3
Glass 1	10.646	10.650	10.654
Glass 2	10.656	10.648	10.651
Glass 3	10.675	10.657	10.653
Glass 4	10.654	10.660	10.666
Glass 5	10.652	10.668	10.656
Glass 6	10.649	10.661	10.656
Glass 7	10.654	10.660	10.672
Glass 8	10.646	10.650	10.640
Glass 9	10.644	10.652	10.663
Glass 10	10.663	10.664	10.657
Glass 11	10.662	10.641	10.647
Glass 12	10.641	10.651	10.646
Glass 13	10.650	10.649	10.653
Glass 14	10.651	10.657	10.641
Glass 15	10.651	10.650	10.651
Glass 16	10.646	10.653	10.644
Glass 17	10.664	10.663	10.651
Glass 18	10.644	10.657	10.650
Glass 19	10.655	10.641	10.645
Glass 20	10.650	10.650	10.639

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	0.001879851	19	9.89395E-05	2.1219835	0.0224803	1.8528918
Within groups	0.001865039	40	4.6626E-05			
Total	0.00374489	59				
within-sd	0.00683					
effective n	3.00					
s_bb	0.004175866					
s_bb_min	0.00186					
u_bb	0.00418					
u_bb(rel.)	0.03920					

Cadmium

	1	2	3
Glass 1	0.00068	0.00087	0.00075
Glass 2	0.00076	0.00071	0.00066
Glass 3	0.00070	0.00060	0.00072
Glass 4	0.00046	0.00051	0.00065
Glass 5	0.00079	0.00060	0.00072
Glass 6	0.00052	0.00087	0.00059
Glass 7	0.00078	0.00077	0.00078
Glass 8	0.00068	0.00062	0.00076
Glass 9	0.00070	0.00078	0.00079
Glass 10	0.00093	0.00078	0.00059
Glass 11	0.00083	0.00051	0.00068
Glass 12	0.00063	0.00077	0.00067
Glass 13	0.00074	0.00064	0.00056
Glass 14	0.00058	0.00067	0.00084
Glass 15	0.00087	0.00074	0.00055
Glass 16	0.00068	0.00070	0.00068
Glass 17	0.00082	0.00063	0.00078
Glass 18	0.00077	0.00078	0.00075
Glass 19	0.00070	0.00078	0.00081
Glass 20	0.00074	0.00066	0.00071

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.853E-07	19	9.7526E-09	0.9739577	0.5076856	1.8528918
Within groups	4.00536E-07	40	1.0013E-08			
Total	5.85836E-07	59				
within-sd	0.00010					
effective n	3.00					
s_bb	0					
s_bb_min	0.00003					
u_bb	0.00003					
u_bb(rel.)	3.86980					

Cobalt

	1	2	3
Glass 1	0.0233	0.0232	0.0232
Glass 2	0.0234	0.0236	0.0231
Glass 3	0.0234	0.0233	0.0233
Glass 4	0.0236	0.0231	0.0232
Glass 5	0.0235	0.0230	0.0233
Glass 6	0.0233	0.0232	0.0233
Glass 7	0.0234	0.0232	0.0233
Glass 8	0.0230	0.0230	0.0232
Glass 9	0.0236	0.0232	0.0233
Glass 10	0.0232	0.0235	0.0233
Glass 11	0.0235	0.0231	0.0233
Glass 12	0.0234	0.0235	0.0234
Glass 13	0.0235	0.0232	0.0234
Glass 14	0.0231	0.0234	0.0233
Glass 15	0.0233	0.0234	0.0233
Glass 16	0.0235	0.0234	0.0232
Glass 17	0.0237	0.0233	0.0231
Glass 18	0.0236	0.0234	0.0236
Glass 19	0.0230	0.0230	0.0234
Glass 20	0.0234	0.0233	0.0232

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	5.34007E-07	19	2.8106E-08	0.9612948	0.5207559	1.8528918
Within groups	1.16949E-06	40	2.9237E-08			
Total	1.7035E-06	59				
within-sd	0.00017					
effective n	3.00					
s_bb	0					
s_bb_min	0.00005					
u_bb	0.00005					
u_bb(rel.)	0.20022					

Chromium

	1	2	3
Glass 1	0.1845	0.1850	0.1846
Glass 2	0.1851	0.1852	0.1846
Glass 3	0.1851	0.1846	0.1848
Glass 4	0.1842	0.1848	0.1848
Glass 5	0.1840	0.1847	0.1848
Glass 6	0.1845	0.1850	0.1848
Glass 7	0.1843	0.1842	0.1849
Glass 8	0.1849	0.1845	0.1853
Glass 9	0.1843	0.1839	0.1846
Glass 10	0.1846	0.1853	0.1850
Glass 11	0.1848	0.1845	0.1852
Glass 12	0.1850	0.1848	0.1849
Glass 13	0.1848	0.1847	0.1848
Glass 14	0.1842	0.1846	0.1847
Glass 15	0.1852	0.1855	0.1843
Glass 16	0.1850	0.1850	0.1847
Glass 17	0.1844	0.1854	0.1842
Glass 18	0.1845	0.1850	0.1847
Glass 19	0.1841	0.1845	0.1853
Glass 20	0.1840	0.1853	0.1842

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	2.1821E-06	19	1.1485E-07	0.754491	0.7418266	1.8528918
Within groups	6.0887E-06	40	1.5222E-07			
Total	8.2707E-06	59				
within-sd	0.00039					
effective n	3.00					
s_bb	0					
s_bb_min	0.00011					
u_bb	0.00011					
u_bb(rel.)	0.05766					

Copper

	1	2	3
Glass 1	0.00359	0.00360	0.00348
Glass 2	0.00364	0.00372	0.00350
Glass 3	0.00366	0.00359	0.00366
Glass 4	0.00359	0.00365	0.00363
Glass 5	0.00358	0.00358	0.00346
Glass 6	0.00361	0.00375	0.00365
Glass 7	0.00357	0.00349	0.00350
Glass 8	0.00361	0.00355	0.00355
Glass 9	0.00361	0.00358	0.00357
Glass 10	0.00364	0.00355	0.00360
Glass 11	0.00355	0.00365	0.00357
Glass 12	0.00357	0.00363	0.00350
Glass 13	0.00351	0.00360	0.00369
Glass 14	0.00361	0.00357	0.00361
Glass 15	0.00355	0.00363	0.00356
Glass 16	0.00358	0.00358	0.00360
Glass 17	0.00365	0.00372	0.00359
Glass 18	0.00353	0.00367	0.00356
Glass 19	0.00358	0.00351	0.00356
Glass 20	0.00351	0.00355	0.00364

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	8.05053E-08	19	4.23712E-09	1.2738746	0.2533554	1.8528918
Within groups	1.33047E-07	40	3.32617E-09			
Total	2.13552E-07	59				
within-sd	0.00006					
effective n	3.00					
s_bb	1.74256E-05					
s_bb_min	0.00002					
u_bb	0.00002					
u_bb(rel.)	0.48548					

Chlorine

	1	2	3
Glass 1	0.0164	0.0163	0.0162
Glass 2	0.0165	0.0167	0.0153
Glass 3	0.0162	0.0166	0.0158
Glass 4	0.0158	0.0161	0.0160
Glass 5	0.0161	0.0160	0.0172
Glass 6	0.0158	0.0171	0.0164
Glass 7	0.0159	0.0159	0.0155
Glass 8	0.0164	0.0159	0.0167
Glass 9	0.0168	0.0164	0.0162
Glass 10	0.0159	0.0167	0.0157
Glass 11	0.0164	0.0160	0.0160
Glass 12	0.0165	0.0163	0.0159
Glass 13	0.0160	0.0163	0.0160
Glass 14	0.0161	0.0161	0.0163
Glass 15	0.0155	0.0161	0.0165
Glass 16	0.0161	0.0166	0.0163
Glass 17	0.0159	0.0162	0.0168
Glass 18	0.0163	0.0164	0.0164
Glass 19	0.0161	0.0151	0.0163
Glass 20	0.0163	0.0163	0.0165

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	2.001E-06	19	1.053E-07	0.6365481	0.8544682	1.8528918
Within groups	6.618E-06	40	1.655E-07			
Total	8.619E-06	59				
within-sd	0.00041					
effective n	3.00					
s_bb	0					
s_bb_min	0.00011					
u_bb	0.00011					
u_bb(rel.)	0.68533					

Iron

	1	2	3
Glass 1	0.560	0.560	0.558
Glass 2	0.561	0.560	0.560
Glass 3	0.560	0.561	0.559
Glass 4	0.560	0.560	0.561
Glass 5	0.560	0.560	0.559
Glass 6	0.560	0.560	0.561
Glass 7	0.558	0.559	0.559
Glass 8	0.558	0.559	0.559
Glass 9	0.559	0.560	0.560
Glass 10	0.561	0.559	0.559
Glass 11	0.559	0.559	0.559
Glass 12	0.559	0.559	0.559
Glass 13	0.561	0.559	0.558
Glass 14	0.559	0.558	0.558
Glass 15	0.558	0.559	0.559
Glass 16	0.559	0.559	0.558
Glass 17	0.561	0.560	0.560
Glass 18	0.559	0.559	0.559
Glass 19	0.558	0.558	0.557
Glass 20	0.559	0.559	0.559

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	3.6145E-05	19	1.9024E-06	4.4046617	3.918E-05	1.8528918
Within groups	1.7276E-05	40	4.319E-07			
Total	5.3421E-05	59				
within-sd	0.00066					
effective n	3.00					
s_bb	0.00070011					
s_bb_min	0.00018					
u_bb	0.00070					
u_bb(rel.)	0.12519					

Potassium

	1	2	3
Glass 1	0.695	0.694	0.695
Glass 2	0.693	0.692	0.694
Glass 3	0.694	0.700	0.696
Glass 4	0.694	0.694	0.693
Glass 5	0.695	0.693	0.693
Glass 6	0.696	0.694	0.694
Glass 7	0.695	0.694	0.693
Glass 8	0.693	0.691	0.692
Glass 9	0.693	0.696	0.695
Glass 10	0.693	0.695	0.694
Glass 11	0.696	0.696	0.694
Glass 12	0.693	0.693	0.692
Glass 13	0.698	0.695	0.692
Glass 14	0.694	0.694	0.691
Glass 15	0.693	0.695	0.695
Glass 16	0.695	0.692	0.693
Glass 17	0.694	0.698	0.694
Glass 18	0.693	0.692	0.694
Glass 19	0.692	0.691	0.693
Glass 20	0.695	0.695	0.695

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	7.78869E-05	19	4.09931E-06	1.8928788	0.0444309	1.8528918
Within groups	8.66259E-05	40	2.16565E-06			
Total	0.000164513	59				
within-sd	0.00147					
effective n	3.00					
s_bb	0.000802841					
s_bb_min	0.00040					
u_bb	0.00080					
u_bb(rel.)	0.11568					

Magnesium

	1	2	3
Glass 1	1.915	1.912	1.896
Glass 2	1.917	1.903	1.899
Glass 3	1.921	1.923	1.900
Glass 4	1.913	1.919	1.917
Glass 5	1.910	1.910	1.910
Glass 6	1.914	1.910	1.908
Glass 7	1.906	1.911	1.908
Glass 8	1.905	1.901	1.894
Glass 9	1.903	1.903	1.902
Glass 10	1.912	1.902	1.903
Glass 11	1.901	1.900	1.896
Glass 12	1.901	1.899	1.898
Glass 13	1.919	1.898	1.903
Glass 14	1.907	1.901	1.894
Glass 15	1.894	1.892	1.891
Glass 16	1.903	1.899	1.903
Glass 17	1.907	1.896	1.900
Glass 18	1.893	1.893	1.899
Glass 19	1.910	1.898	1.897
Glass 20	1.899	1.898	1.897

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	0.00223862	19	0.00011782	3.237463	0.000866	1.8528918
Within groups	0.00145573	40	3.6393E-05			
Total	0.00369435	59				
within-sd	0.00603					
effective n	3.00					
s_bb	0.00520988					
s_bb_min	0.00165					
u_bb	0.00521					
u_bb(rel.)	0.27364					

Manganese

	1	2	3
Glass 1	0.2361	0.2371	0.2375
Glass 2	0.2370	0.2364	0.2368
Glass 3	0.2382	0.2375	0.2369
Glass 4	0.2378	0.2377	0.2373
Glass 5	0.2367	0.2369	0.2359
Glass 6	0.2367	0.2367	0.2376
Glass 7	0.2372	0.2366	0.2373
Glass 8	0.2370	0.2366	0.2366
Glass 9	0.2363	0.2364	0.2366
Glass 10	0.2371	0.2374	0.2368
Glass 11	0.2366	0.2362	0.2365
Glass 12	0.2360	0.2373	0.2373
Glass 13	0.2368	0.2365	0.2364
Glass 14	0.2367	0.2377	0.2360
Glass 15	0.2369	0.2362	0.2369
Glass 16	0.2367	0.2371	0.2363
Glass 17	0.2370	0.2363	0.2371
Glass 18	0.2360	0.2375	0.2372
Glass 19	0.2367	0.2362	0.2366
Glass 20	0.2369	0.2370	0.2370

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	5.68249E-06	19	2.9908E-07	1.269677	0.256088	1.8528918
Within groups	9.42218E-06	40	2.3555E-07			
Total	1.51047E-05	59				
within-sd	0.00049					
effective n	3.00					
s_bb	0.000145515					
s_bb_min	0.00013					
u_bb	0.00015					
u_bb(rel.)	0.06144					

Sodium

	1	2	3
Glass 1	11.829	11.826	11.655
Glass 2	11.846	11.703	11.695
Glass 3	11.904	11.895	11.715
Glass 4	11.874	11.874	11.860
Glass 5	11.825	11.820	11.813
Glass 6	11.818	11.811	11.795
Glass 7	11.813	11.811	11.803
Glass 8	11.794	11.761	11.716
Glass 9	11.765	11.756	11.749
Glass 10	11.792	11.707	11.674
Glass 11	11.620	11.601	11.622
Glass 12	11.669	11.668	11.665
Glass 13	11.886	11.695	11.725
Glass 14	11.764	11.738	11.678
Glass 15	11.588	11.588	11.623
Glass 16	11.711	11.647	11.658
Glass 17	11.703	11.665	11.677
Glass 18	11.652	11.657	11.659
Glass 19	11.817	11.705	11.691
Glass 20	11.682	11.678	11.724

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	0.30750337	19	0.016184388	5.9926314	1.007E-06	1.8528918
Within groups	0.10802859	40	0.002700715			
Total	0.41553197	59				
within-sd	0.05197					
effective n	3.00					
s_bb	0.06704146					
s_bb_min	0.01419					
u_bb	0.06704					
u_bb(rel.)	0.57125					

Nickel

	1	2	3
Glass 1	0.00292	0.00282	0.00285
Glass 2	0.00296	0.00301	0.00282
Glass 3	0.00295	0.00292	0.00289
Glass 4	0.00290	0.00281	0.00300
Glass 5	0.00288	0.00286	0.00281
Glass 6	0.00297	0.00289	0.00296
Glass 7	0.00295	0.00293	0.00308
Glass 8	0.00286	0.00290	0.00283
Glass 9	0.00287	0.00287	0.00293
Glass 10	0.00304	0.00282	0.00296
Glass 11	0.00300	0.00292	0.00279
Glass 12	0.00283	0.00270	0.00293
Glass 13	0.00290	0.00289	0.00291
Glass 14	0.00278	0.00298	0.00295
Glass 15	0.00289	0.00305	0.00289
Glass 16	0.00291	0.00298	0.00293
Glass 17	0.00289	0.00282	0.00289
Glass 18	0.00287	0.00298	0.00278
Glass 19	0.00289	0.00288	0.00291
Glass 20	0.00280	0.00288	0.00282

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	9.80396E-08	19	5.15998E-09	0.963486	0.5184846	1.8528918
Within groups	2.14221E-07	40	5.35553E-09			
Total	3.12261E-07	59				
within-sd	0.00007					
effective n	3.00					
s_bb	0					
s_bb_min	0.00002					
u_bb	0.00002					
u_bb(rel.)	0.68942					

Phosphor

	1	2	3
Glass 1	0.0288	0.0294	0.0278
Glass 2	0.0250	0.0236	0.0240
Glass 3	0.0284	0.0295	0.0306
Glass 4	0.0290	0.0285	0.0301
Glass 5	0.0290	0.0298	0.0295
Glass 6	0.0246	0.0240	0.0243
Glass 7	0.0249	0.0250	0.0249
Glass 8	0.0240	0.0246	0.0247
Glass 9	0.0234	0.0247	0.0235
Glass 10	0.0240	0.0242	0.0244
Glass 11	0.0279	0.0284	0.0280
Glass 12	0.0294	0.0287	0.0294
Glass 13	0.0249	0.0249	0.0248
Glass 14	0.0274	0.0274	0.0274
Glass 15	0.0285	0.0294	0.0294
Glass 16	0.0283	0.0291	0.0279
Glass 17	0.0239	0.0241	0.0253
Glass 18	0.0295	0.0292	0.0295
Glass 19	0.0299	0.0287	0.0292
Glass 20	0.0234	0.0242	0.0252

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	0.00031525	19	1.65921E-05	49.55787	6.415E-22	1.8528918
Within groups	1.33921E-05	40	3.34803E-07			
Total	0.000328642	59				
within-sd	0.00058					
effective n	3.00					
s_bb	0.002327897					
s_bb_min	0.00016					
u_bb	0.00233					
u_bb(rel.)	8.66584					

Lead

	1	2	3
Glass 1	0.0106	0.0107	0.0106
Glass 2	0.0106	0.0106	0.0107
Glass 3	0.0107	0.0107	0.0106
Glass 4	0.0105	0.0108	0.0106
Glass 5	0.0107	0.0105	0.0106
Glass 6	0.0105	0.0105	0.0108
Glass 7	0.0106	0.0107	0.0105
Glass 8	0.0105	0.0104	0.0105
Glass 9	0.0107	0.0108	0.0106
Glass 10	0.0107	0.0106	0.0106
Glass 11	0.0106	0.0106	0.0106
Glass 12	0.0106	0.0107	0.0106
Glass 13	0.0105	0.0105	0.0107
Glass 14	0.0107	0.0106	0.0105
Glass 15	0.0106	0.0105	0.0105
Glass 16	0.0105	0.0106	0.0106
Glass 17	0.0105	0.0106	0.0106
Glass 18	0.0105	0.0106	0.0106
Glass 19	0.0106	0.0106	0.0106
Glass 20	0.0106	0.0106	0.0106

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.49461E-07	19	7.86636E-09	1.3133183	0.2288152	1.8528918
Within groups	2.39587E-07	40	5.98968E-09			
Total	3.89048E-07	59				
within-sd	0.00008					
effective n	3.00					
s_bb	2.50112E-05					
s_bb_min	0.00002					
u_bb	0.00003					
u_bb(rel.)	0.23608					

Strontium

	1	2	3
Glass 1	0.0265	0.0266	0.0265
Glass 2	0.0141	0.0141	0.0141
Glass 3	0.0140	0.0141	0.0141
Glass 4	0.0143	0.0143	0.0144
Glass 5	0.0255	0.0255	0.0254
Glass 6	0.0140	0.0140	0.0141
Glass 7	0.0143	0.0143	0.0143
Glass 8	0.0142	0.0142	0.0143
Glass 9	0.0140	0.0140	0.0140
Glass 10	0.0143	0.0143	0.0143
Glass 11	0.0263	0.0263	0.0262
Glass 12	0.0257	0.0258	0.0258
Glass 13	0.0142	0.0143	0.0143
Glass 14	0.0252	0.0252	0.0252
Glass 15	0.0276	0.0277	0.0276
Glass 16	0.0260	0.0260	0.0259
Glass 17	0.0140	0.0140	0.0140
Glass 18	0.0256	0.0254	0.0255
Glass 19	0.0270	0.0270	0.0270
Glass 20	0.0140	0.0140	0.0140

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between gro	0.002153681	19	0.000113352	58764.395	6.826E-83	1.8528918
Within group	7.71567E-08	40	1.92892E-09			
Total	0.002153758	59				
within-sd	0.00004					
effective n	3.00					
s_bb	0.006146807					
s_bb_min	0.00001					
u_bb	0.00615					
u_bb(rel.)	31.43142					

Sulfur

	1	2	3
Glass 1	0.0705	0.0696	0.0707
Glass 2	0.0700	0.0688	0.0693
Glass 3	0.0697	0.0701	0.0701
Glass 4	0.0709	0.0711	0.0711
Glass 5	0.0699	0.0712	0.0704
Glass 6	0.0704	0.0702	0.0697
Glass 7	0.0717	0.0711	0.0710
Glass 8	0.0706	0.0710	0.0711
Glass 9	0.0697	0.0695	0.0701
Glass 10	0.0711	0.0703	0.0709
Glass 11	0.0704	0.0695	0.0701
Glass 12	0.0690	0.0701	0.0700
Glass 13	0.0707	0.0705	0.0704
Glass 14	0.0705	0.0710	0.0715
Glass 15	0.0698	0.0693	0.0711
Glass 16	0.0710	0.0701	0.0710
Glass 17	0.0697	0.0711	0.0707
Glass 18	0.0693	0.0696	0.0700
Glass 19	0.0699	0.0704	0.0697
Glass 20	0.0682	0.0696	0.0693

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between gro	2.00227E-05	19	1.05383E-06	4.1481207	7.5E-05	1.8528918
Within group	1.0162E-05	40	2.54049E-07			
Total	3.01847E-05	59				
within-sd	0.00050					
effective n	3.00					
s_bb	0.000516326					
s_bb_min	0.00014					
u_bb	0.00052					
u_bb(rel.)	0.73491					

Antimony

	1	2	3
Glass 1	0.00518	0.00501	0.00535
Glass 2	0.00508	0.00518	0.00507
Glass 3	0.00507	0.00522	0.00523
Glass 4	0.00507	0.00509	0.00516
Glass 5	0.00514	0.00520	0.00514
Glass 6	0.00519	0.00517	0.00524
Glass 7	0.00498	0.00507	0.00508
Glass 8	0.00524	0.00512	0.00515
Glass 9	0.00521	0.00522	0.00503
Glass 10	0.00511	0.00510	0.00529
Glass 11	0.00505	0.00520	0.00505
Glass 12	0.00508	0.00507	0.00506
Glass 13	0.00528	0.00515	0.00527
Glass 14	0.00506	0.00520	0.00518
Glass 15	0.00506	0.00503	0.00522
Glass 16	0.00514	0.00523	0.00511
Glass 17	0.00522	0.00509	0.00513
Glass 18	0.00521	0.00509	0.00513
Glass 19	0.00508	0.00522	0.00507
Glass 20	0.00497	0.00507	0.00528

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	1.1512E-07	19	6.05889E-09	0.8042602	0.6891581	1.8528918
Within groups	3.0134E-07	40	7.5335E-09			
Total	4.1646E-07	59				
within-sd	0.00009					
effective n	3.00					
s_bb	0					
s_bb_min	0.00002					
u_bb	0.00002					
u_bb(rel.)	0.46111					

Titanium

	1	2	3
Glass 1	0.0326	0.0326	0.0322
Glass 2	0.0325	0.0319	0.0322
Glass 3	0.0326	0.0322	0.0325
Glass 4	0.0322	0.0322	0.0324
Glass 5	0.0326	0.0325	0.0326
Glass 6	0.0327	0.0324	0.0325
Glass 7	0.0323	0.0326	0.0319
Glass 8	0.0323	0.0324	0.0319
Glass 9	0.0324	0.0323	0.0323
Glass 10	0.0321	0.0325	0.0326
Glass 11	0.0325	0.0327	0.0323
Glass 12	0.0325	0.0324	0.0326
Glass 13	0.0324	0.0324	0.0323
Glass 14	0.0324	0.0326	0.0321
Glass 15	0.0328	0.0323	0.0323
Glass 16	0.0325	0.0324	0.0324
Glass 17	0.0325	0.0327	0.0325
Glass 18	0.0323	0.0325	0.0326
Glass 19	0.0324	0.0323	0.0324
Glass 20	0.0323	0.0324	0.0324

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between gro	6.91162E-07	19	3.6377E-08	1.0985832	0.387917	1.8528918
Within group	1.3245E-06	40	3.3113E-08			
Total	2.01566E-06	59				
within-sd	0.00018					
effective n	3.00					
s_bb	3.29866E-05					
s_bb_min	0.00005					
u_bb	0.00005					
u_bb(rel.)	0.15333					

Zinc

	1	2	3
Glass 1	0.00976	0.00980	0.00965
Glass 2	0.00982	0.00976	0.00982
Glass 3	0.00967	0.00972	0.00977
Glass 4	0.00962	0.00947	0.00966
Glass 5	0.00985	0.00974	0.00987
Glass 6	0.00960	0.00982	0.00959
Glass 7	0.00956	0.00956	0.00971
Glass 8	0.00982	0.00966	0.00966
Glass 9	0.00969	0.00978	0.00982
Glass 10	0.00970	0.00986	0.00957
Glass 11	0.00962	0.00977	0.00972
Glass 12	0.00988	0.00974	0.00970
Glass 13	0.00964	0.00984	0.00972
Glass 14	0.00963	0.00962	0.00957
Glass 15	0.00965	0.00968	0.00967
Glass 16	0.00970	0.00957	0.00977
Glass 17	0.00971	0.00995	0.00995
Glass 18	0.00990	0.00979	0.00986
Glass 19	0.00972	0.00974	0.00955
Glass 20	0.00961	0.00975	0.00977

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	3.39878E-07	19	1.78883E-08	2.2237046	0.0165952	1.8528918
Within groups	3.21775E-07	40	8.04438E-09			
Total	6.61654E-07	59				
within-sd	0.00009					
effective n	3.00					
s_bb	5.72828E-05					
s_bb_min	0.00002					
u_bb	0.00006					
u_bb(rel.)	0.58940					

Zirconium

	1	2	3
Glass 1	0.00402	0.00302	0.00162
Glass 2	0.00161	0.00212	0.00254
Glass 3	0.00239	0.00185	0.00081
Glass 4	0.00216	0.00220	0.00185
Glass 5	0.00247	0.00162	0.00130
Glass 6	0.00160	0.00233	0.00128
Glass 7	0.00270	0.00142	0.00249
Glass 8	0.00175	0.00156	0.00254
Glass 9	0.00170	0.00211	0.00142
Glass 10	0.00323	0.00255	0.00128
Glass 11	0.00190	0.00158	0.00216
Glass 12	0.00188	0.00271	0.00134
Glass 13	0.00283	0.00196	0.00232
Glass 14	0.00135	0.00216	0.00314
Glass 15	0.00059	0.00240	0.00117
Glass 16	0.00155	0.00198	0.00172
Glass 17	0.00164	0.00312	0.00147
Glass 18	0.00104	0.00243	0.00236
Glass 19	0.00159	0.00226	0.00089
Glass 20	0.00217	0.00146	0.00236

Source of variation	*sums of squares (SS)*	*degrees of freedom (df)*	*Mean squares (MS)*	*F-value*	*P-value*	*critical F-value*
Between groups	6.2134E-06	19	3.27021E-07	0.691555	0.804758	1.8528918
Within groups	1.89151E-05	40	4.72878E-07			
Total	2.51285E-05	59				
within-sd	0.00069					
effective n	3.00					
s_bb	0					
s_bb_min	0.00019					
u_bb	0.00019					
u_bb(rel.)	9.46166					