Electronic supplementary information

Multi-element LA-ICP-MS analysis of the clay fraction in archaeological pottery provenance studies: a methodological investigation

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Table S1. Overview of the sediments – reference code, geological formation, member, location and method of sampling.

Reference code	Formation	Member	Location	Sampling method
RU01600	Boom	Putte	Rumst	Bulk
ST01600	Boom	Putte	Steendorp	Bulk
KR01600	Kortrijk	Aalbeke	Kortrijk	Bulk
BE01600	Waalre	Tegelen	Berghoeve	Bulk
BO01600	*unknown*	*unknown*	Boudewijn quarry	Bulk
DN01600	Vlaanderen	Calais	Doelpolder Noord	Drill core[44]
DN02600	Vlaanderen	Calais	Doelpolder Noord	Drill core[44]
DM01600	Vlaanderen	Calais	Doel site M	Pollen core[45]
BS01900	Vlaanderen	Calais	Bazel Sluis (SEQ B)	Pollen core[46]
BS02600	*unknown*	*unknown*	Bazel Sluis (SEQ A)	Pollen core[46]

Table S2. LOD values based on monitoring gas blanks between the samples and calculated according to the IUPAC equation for blank signals with low count rates.[1]

	LOD (µg/g)		
	External calibration *vs.* glass	**External calibration *vs.* NORC**	**sediments**
^{7}Li	0.8	0.8	1
^{11}B	2	-	3
^{23}Na	8	10	50
^{25}Mg	10	10	10
^{27}Al	2	2	2
^{29}Si	400	800	400
^{39}K	10	40	50
^{44}Ca	90	600	200
^{45}Sc	0.7	0.6	4
^{49}Ti	10	10	7
^{51}V	0.7	0.8	0.4
^{53}Cr	7	7	3
^{55}Mn	0.5	0.9	0.7
^{57}Fe	30	50	30
^{59}Co	0.7	0.7	0.4
^{60}Ni	4	4	2
^{65}Cu	3	6	2
^{67}Zn	20	30	20
^{85}Rb	0.4	0.5	0.4
^{88}Sr	0.3	0.3	0.2
^{89}Y	0.3	-	0.1
^{90}Zr	0.7	0.9	0.3
^{93}Nb	0.4	-	0.2
^{118}Sn	0.6	-	0.3
^{121}Sb	0.6	0.6	0.4
^{133}Cs	0.2	0.2	0.3
^{137}Ba	1	2	0.8
^{139}La	0.2	0.3	0.09
^{140}Ce	0.2	0.2	0.1
^{141}Pr	0.1	-	0.07
^{146}Nd	0.6	1	0.4
^{147}Sm	0.7	1	0.4
^{153}Eu	0.2	0.3	0.1
^{157}Gd	0.7	-	0.4
^{159}Tb	0.1	0.2	0.05
^{163}Dy	0.4	0.7	0.2
^{165}Ho	0.1	-	0.05
^{166}Er	0.2	-	0.2
^{169}Tm	0.1	-	0.05
^{172}Yb	0.4	0.9	0.2
^{175}Lu	0.1	0.2	0.05
^{178}Hf	0.3	0.7	0.2
^{208}Pb	0.2	-	0.1
^{209}Bi	0.1	-	3
^{232}Th	0.3	0.4	0.05
^{238}U	0.9	0.9	0.05

Table S3. Concentration values, between- and within-measurement relative standard deviations obtained with 4 different calibration methods for 3 measurements of NIST SRM 679 calibrated against 5 glass standards. The corresponding reference values taken from the certificate of the material issued by NIST and from Hein et al.[2] (for those elements for which the certificate did not specify a reference value) are presented as well. The σ-values accompanying the element concentrations from the certificate of NIST SRM were calculated from the 95% tolerance intervals by dividing the difference between the mean and interval borders by 1.96.

	reference values NIST SRM 679		Method 1			Method 2			Method 3			Method 4		
	conc (µg/g)	σ	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)
Li	71.7	3.2	89.9	2	4	112	3	4	118	4	7	122	3	5
B	-	-	69.9	3	8	88.1	4	7	94.1	3	7	94.7	3	7
Na	1304	19	1140	1	7	1450	1	6	1540	1	6	1640	1	6
Mg	7552	45	6460	1	3	8090	2	3	8630	1	3	8260	1	2
Al	110100	1700	85700	0	2	108000	1	2	116000	1	2	115000	1	2
Si	243400	1500	201000	1	2	243400	-	-	260000	1	1	266000	1	1
K	24330	240	21800	2	3	27400	2	3	29200	3	3	28600	3	3
Ca	1628	7	1480	2	4	1850	0	4	1980	1	4	1920	2	4
Sc	21.2	2.6	22.2	1	5	28.2	3	5	30.1	2	4	30.0	0	3
Ti	5770	170	5220	5	11	6590	4	11	7030	5	11	6570	4	9
V	198	32	151	3	3	189	2	3	202	2	3	198	2	3
Cr	109.7	2.5	106	5	4	134	5	5	143	6	5	141	6	4
Mn	1750	80	1360	8	18	1670	4	14	1790	4	13	1660	7	13
Fe	90500	1100	77700	4	6	99200	5	8	106000	4	6	100000	3	5
Co	25.9	0.6	21.3	1	6	26.7	1	6	28.4	2	5	28.3	3	5
Ni	60.2	15.9	54.6	1	6	69.6	2	5	74.5	1	5	74.4	2	5
Cu	28.4	1.1	31.8	5	5	39.9	4	4	43.0	4	3	42.6	4	4
Zn	119	13	122	5	6	157	1	9	166	1	7	167	1	7
Rb	183	17	169	1	2	211	1	4	226	2	3	227	2	3
Sr	73.4	1.3	51.1	7	9	65.2	5	8	69.6	6	7	69.9	6	7
Y	30.6	3.9	22.0	7	12	28.5	7	12	31.0	6	14	30.2	8	12
Zr	162	50	101	12	20	130	5	19	139	4	20	130	10	15
Nb	12.7	5.7	13.4	3	9	17.1	2	8	18.2	3	8	18.3	2	8
Sn	3.20	1.99	3.30	5	5	4.21	4	6	4.48	6	5	5.22	6	4
Sb	0.80	0.08	0.857	7	6	1.09	7	7	1.16	8	7	1.16	8	6
Cs	10.20	0.64	9.44	1	2	11.9	2	3	12.7	3	3	12.7	2	3
Ba	432.2	5.0	333	0	4	422	0	3	452	1	3	451	1	2

Table S3 (continued).

	reference values NIST SRM 679		Method 1			Method 2			Method 3			Method 4		
	conc (µg/g)	σ	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)
Ce	102	8	76.8	6	11	98.0	5	10	105	7	10	105	6	10
Pr	12.4	0.3	8.11	4	10	10.3	5	11	11.1	6	13	11.0	6	11
Nd	49.2	7.8	31.0	6	11	39.4	5	12	42.1	6	12	41.8	8	11
Sm	8.70	0.72	6.10	3	8	7.79	1	9	8.31	2	9	8.27	4	8
Eu	1.77	0.05	1.26	2	12	1.60	2	10	1.70	2	9	1.71	2	10
Gd	8.67	0.21	5.38	2	15	6.84	2	13	7.30	3	13	7.33	2	14
Tb	1.14	0.08	0.775	3	21	0.969	4	17	1.04	7	17	1.01	5	14
Dy	6.59	0.18	4.75	7	19	6.00	8	16	6.41	8	16	6.31	4	16
Ho	1.21	0.04	0.943	6	18	1.23	8	20	1.25	4	15	1.29	6	18
Er	3.58	0.12	2.15	6	17	2.80	7	19	3.00	7	19	3.16	3	19
Tm	0.459	0.025	0.359	4	15	0.465	6	16	0.497	5	15	0.493	5	14
Yb	3.7	0.4	2.47	2	18	3.28	4	23	3.40	3	19	3.38	2	17
Lu	0.511	0.057	0.390	6	20	0.498	8	19	0.532	9	19	0.531	5	19
Hf	4.51	0.13	2.77	15	23	3.68	13	22	3.92	14	22	3.80	15	23
Pb	24.7	1.5	22.9	2	6	28.8	3	7	30.7	2	6	32.7	2	6
Bi	-	-	0.341	3	7	0.425	3	7	0.455	3	7	0.491	4	7
Th	15.9	2.8	8.63	1	7	10.9	1	7	11.7	2	7	13.7	2	7
U	2.78	0.31	2.46	2	11	3.11	3	9	3.27	4	7	3.36	3	9

Table S4. Concentration values, between- and within-measurement relative standard deviations obtained with 4 different calibration methods for 3 measurements of NIST SRM 679 calibrated against matrix-matched NORC. The corresponding reference values taken from the certificate of the material issued by NIST and from Hein et al.[2] (for those elements for which the certificate did not specify a reference value) are presented as well. The σ-values accompanying the element concentrations from the certificate of NIST SRM were calculated from the 95% tolerance intervals by dividing the difference between the mean and interval borders by 1.96.

	reference values NIST SRM 679		Method 1			Method 2			Method 3			Method 4		
	conc (µg/g)	σ	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)
Li	71.7	3.2	73.9	17	4	70.7	17	7	82.0	17	8	81.0	15	4
Na	1304	19	1160	4	4	1100	2	4	1270	2	5	1250	2	5
Mg	7552	45	5480	2	2	5180	4	4	6000	3	2	6010	3	2
Al	110100	1700	94000	1	2	88400	1	3	103000	1	2	103000	1	3
Si	243400	1500	262000	3	3	243400	-	-	284000	1	1	286000	1	2
K	24330	240	23200	4	2	21900	1	3	25500	1	2	25300	1	2
Ca	1628	7	3910	3	4	3770	1	6	4390	1	6	4240	1	5
Sc	21.2	2.6	17.1	3	2	16.2	0	4	18.9	1	3	18.7	1	3
Ti	5770	170	5190	2	11	5030	3	10	5830	3	9	5880	3	9
V	198	32	155	4	2	148	1	3	172	2	2	170	2	2
Cr	109.7	2.5	103	3	4	98.5	3	5	114	3	5	113	3	5
Mn	1750	80	1490	7	16	1460	5	15	1690	5	14	1690	5	12
Fe	90500	1100	82800	3	3	80500	1	7	93000	1	4	90500	1	3
Co	25.9	0.6	21.4	4	5	20.9	4	9	24.0	3	7	21.7	2	6
Ni	60.2	15.9	53.2	4	4	51.0	2	6	59.0	1	4	57.8	1	4
Cu	28.4	1.1	61.7	9	4	58.6	7	4	67.6	7	5	66.1	7	5
Zn	119	13	121	3	7	117	4	8	136	3	7	124	3	6
Rb	183	17	186	2	2	177	1	4	206	0	3	202	0	3
Sr	73.4	1.3	64.3	3	5	61.9	7	6	72.3	6	5	69.6	7	5
Zr	162	50	142	8	19	141	5	19	163	5	18	129	6	18
Sb	0.80	0.08	0.709	3	7	0.672	4	8	0.782	3	8	0.764	4	8
Cs	10.20	0.64	9.94	1	2	9.47	3	3	11.0	3	2	10.8	2	3
Ba	432.2	5.0	454	1	3	441	6	6	508	5	5	484	5	4
La	49.7	3.9	62.6	2	11	61.2	2	9	71.0	1	8	69.6	2	9
Ce	102	8	117	1	12	113	5	8	131	5	8	121	5	10
Nd	49.2	7.8	47.8	4	11	47.1	3	11	54.5	2	10	53.5	2	11
Sm	8.70	0.72	8.86	2	9	8.78	3	12	10.1	2	11	9.97	2	11

Table S4 (continued).

	reference values NIST SRM 679		Method 1			Method 2			Method 3			Method 4		
	conc (µg/g)	σ	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	RSD between (%)	RSD within (%)
Tb	1.14	0.08	1.11	4	9	1.13	10	13	1.31	9	13	1.03	9	13
Dy	6.59	0.18	7.23	3	13	7.10	6	14	8.25	6	13	7.18	6	13
Yb	3.7	0.4	4.76	3	15	4.58	4	16	5.62	4	20	5.32	5	20
Lu	0.511	0.057	0.713	4	13	0.685	7	15	0.798	7	15	0.739	7	14
Hf	4.51	0.13	6.59	3	19	6.16	8	16	7.17	7	15	6.50	6	21
Th	15.9	2.8	14.0	3	9	13.6	3	9	16.0	1	8	14.3	4	10
U	2.78	0.31	2.69	5	9	2.61	3	10	3.03	3	10	2.95	4	11

Table S5. Concentration values and between- and within-measurement relative standard deviations for 4 measurements of a NORC pellet and 9 measurements of a NIST SRM 679 pellet performed between the sediment samples as control, compared to the corresponding reference values from Kuleff and Djingova[3] for NORC and the certificate issued by NIST and Hein et al.[2] for NIST SRM 679 Brick Clay.

	Reference values NORC		NORC pellet			reference values NIST SRM 679		NIST SRM 679 pellet		
	conc (µg/g)	σ	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	σ	conc (µg/g)	RSD between (%)	RSD within (%)
Li	139	-	127	19	4	71.7	3.2	69.9	17	4
B	-	-	93.9	18	11	-	-	70.8	19	9
Na	1400	70	1450	5	7	1304	19	1240	5	6
Mg	7300	-	12300	11	4	7552	45	9720	9	3
Al	94500	3800	125000	16	3	110100	1700	134000	13	3
Si	309000	-	268000	9	2	243400	1500	244000	8	2
K	35500	2000	41800	7	4	24330	240	27600	4	3
Ca	4500	700	2140	9	10	1628	7	1800	14	7
Sc	18.95	1.17	24.4	9	6	21.2	2.6	26.3	9	6
Ti	5940	630	7830	19	14	5770	170	7340	15	5
V	211	26	240	3	5	198	32	183	4	2
Cr	90.7	7.4	105	5	5	109.7	2.5	129	6	3
Mn	253	10	316	8	9	1750	80	1910	10	12
Fe	53300	2000	65100	6	4	90500	1100	105000	5	4
Co	20.2	0.6	25.3	13	6	25.9	0.6	26.5	5	6
Ni	75.9	-	93.4	7	7	60.2	15.9	65.6	4	4
Cu	36	-	22.6	8	10	28.4	1.1	37.8	4	5
Zn	101	6	157	16	9	119	13	149	6	7
Rb	184	16	207	12	5	183	17	204	9	2
Sr	66	14	76.3	17	7	73.4	1.3	76.4	17	6
Y	-	-	26.4	25	22	30.6	3.9	33.6	15	17
Zr	170	-	171	16	21	162	50	152	20	22
Nb	-	-	24.3	23	18	12.7	5.7	20.1	15	8
Sn	-	-	5.47	25	19	3.20	1.99	3.88	6	6
Sb	1.39	0.09	3.02	38	15	0.80	0.08	1.30	23	11
Cs	10.6	0.7	12.3	17	6	10.20	0.64	11.1	11	3

Table S5 (continued).

	Reference values NORC		NORC pellet			reference values NIST SRM 679		NIST SRM 679 pellet		
	conc (µg/g)	σ	conc (µg/g)	RSD between (%)	RSD within (%)	conc (µg/g)	σ	conc (µg/g)	RSD between (%)	RSD within (%)
La	50.9	3.1	45.2	10	28	49.7	3.9	52.2	21	13
Ce	109.7	6.5	111	5	25	102	8	114	17	10
Pr	-	-	10.6	11	27	12.4	0.3	12.2	18	11
Nd	42.3	2.8	38.4	12	27	49.2	7.8	44.9	19	11
Sm	8.0	0.6	7.75	11	32	8.70	0.72	9.00	21	10
Eu	1.54	0.14	1.48	13	27	1.77	0.05	1.77	18	9
Gd	-		6.04	14	32	8.67	0.21	7.49	19	11
Tb	1.06	0.04	0.914	28	33	1.14	0.08	1.10	19	13
Dy	7.4	1.4	5.85	31	34	6.59	0.18	6.69	22	13
Ho	-	-	1.10	26	30	1.21	0.04	1.23	20	13
Er	-	-	3.30	34	24	3.58	0.12	3.70	22	13
Tm	-	-	0.488	29	23	0.459	0.025	0.520	21	15
Yb	4.27	0.16	3.36	34	21	3.7	0.4	3.53	21	13
Lu	0.64	0.09	0.522	34	23	0.511	0.057	0.536	24	18
Hf	7.16	0.54	4.16	31	12	4.51	0.13	3.89	21	17
Pb	-	-	18.3	15	19	24.7	1.5	27.7	12	4
Bi	-	-	1.50	25	41	-	-	0.539	46	38
Th	15.1	0.8	14.5	14	22	15.9	2.8	13.8	19	10
U	2.96	0.34	3.61	24	26	2.78	0.31	2.87	17	10

Table S6.Concentration values and within-measurement relative standard deviations for 3 measurements of each sediment and for all elements monitored. All element concentrations are expressed in µg/g.

	Li	RSD (%)	B	RSD (%)	Na	RSD (%)	Mg	RSD (%)	Al	RSD (%)	Si	RSD (%)	K	RSD (%)
BSO2600a	41.4	17	132	21	4850	39	13000	12	66600	17	229000	8	23300	16
BSO2600b	37.5	15	104	46	4110	55	12700	6	66000	2	249000	3	24600	11
BSO2600c	41.6	32	128	37	5020	31	12900	20	61600	14	243000	7	23500	16
BS01900a	38.9	4	118	16	8070	26	16400	11	70600	8	251000	7	21100	16
BS01900b	38.6	51	156	10	6650	14	13300	40	75500	12	191000	40	19100	41
BS01900c	36.4	20	147	26	8050	21	15000	13	82300	7	252000	4	21600	13
DM01600a	57.9	5	116	27	4920	12	15300	5	108000	3	289000	1	33100	6
DM01600b	55.8	6	107	19	4990	20	15200	2	105000	4	290000	2	32000	6
DM01600c	56.2	7	97.6	12	5400	20	14600	5	107000	4	289000	2	33700	2
DN01600a	72.7	9	170	3	10400	12	17200	6	93400	6	267000	3	30200	4
DN01600b	66.9	7	151	12	10500	11	17200	4	98300	2	267000	2	31100	6
DN01600c	68.2	5	142	6	13800	24	17300	2	95200	4	262000	1	31700	6
DN02600a	59.7	6	80.7	10	5680	22	20500	6	120000	5	227000	4	31000	5
DN02600b	62.7	8	79.5	7	7040	23	21300	7	121000	8	226000	5	30800	9
DN02600c	59.5	7	82.4	9	6610	18	21400	8	114000	4	221000	3	31400	7
RU01600a	115	6	140	26	2860	46	16400	4	140000	5	249000	2	40300	7
RU01600b	114	5	110	5	1620	16	17500	4	153000	4	246000	2	38700	5
RU01600c	110	4	125	8	2400	22	16700	2	147000	6	249000	2	41100	4
ST01600a	124	8	145	7	1840	8	17500	3	134000	3	256000	2	37600	5
ST01600b	120	9	163	17	3700	18	17000	6	131000	6	255000	2	40300	7
ST01600c	115	6	149	10	1620	24	17000	4	130000	6	255000	2	40800	3
KR01600a	86.2	5	92.0	10	1990	7	21500	5	147000	5	237000	1	40300	7
KR01600b	79.0	8	75.4	6	1840	11	20900	4	148000	1	237000	1	38100	7
KR01600c	70.6	5	69.7	9	1920	9	22000	3	152000	3	233000	2	36000	4
BE01600a	66.3	6	154	9	1780	9	11400	3	135000	6	270000	3	38200	6
BE01600b	59.2	5	160	14	1440	34	11800	2	152000	2	261000	3	36400	7
BE01600c	67.9	8	124	8	1630	34	12000	4	141000	11	262000	2	37400	8
BO01600a	48.4	11	100	23	1850	15	10200	5	132000	9	271000	6	35300	6
BO01600b	45.2	5	72.7	13	2550	35	10000	5	132000	6	272000	2	34900	10
BO01600c	35.3	5	64.5	15	1610	16	13800	7	179000	5	224000	1	27800	8

Table S6 (continued).

	Ca	RSD (%)	Sc	RSD (%)	Ti	RSD (%)	V	RSD (%)	Cr	RSD (%)	Mn	RSD (%)	Fe	RSD (%)
BSO2600a	25200	9	16.5	10	3510	34	194	13	153	15	1210	51	187000	14
BSO2600b	26700	5	17.0	11	2760	12	171	4	159	10	784	20	161000	6
BSO2600c	27000	13	17.5	6	3020	17	184	7	169	16	809	28	168000	13
BS01900a	77500	15	17.0	10	7640	42	200	11	145	11	970	31	93300	20
BS01900b	80700	20	16.7	10	3760	33	231	48	177	17	1230	28	110000	18
BS01900c	70500	9	19.3	12	3770	27	195	5	157	11	1370	32	99300	16
DM01600a	9250	13	23.2	7	5550	8	265	5	199	8	319	7	56300	6
DM01600b	10600	12	22.5	5	6560	21	274	4	201	6	302	9	56300	4
DM01600c	9070	9	23.7	7	5970	18	274	5	200	4	301	7	56200	3
DN01600a	16000	21	18.8	6	4780	8	245	5	174	7	1330	9	92600	5
DN01600b	15500	6	19.8	3	4320	3	239	2	175	5	1280	8	89800	5
DN01600c	19000	23	20.5	3	4670	14	244	5	178	4	1320	8	94300	3
DN02600a	36400	22	23.3	7	5930	31	210	5	158	10	777	59	92300	8
DN02600b	31500	40	24.0	7	6290	19	217	6	158	10	447	24	88700	7
DN02600c	44600	29	22.7	6	7560	25	216	7	158	7	1150	0	93000	14
RU01600a	3210	33	25.2	6	6810	15	251	9	221	5	179	11	65700	5
RU01600b	2960	6	27.6	5	7060	6	242	5	212	6	173	6	59400	8
RU01600c	2530	22	25.7	5	7590	11	250	3	223	2	168	5	58000	11
ST01600a	7050	10	23.2	7	7600	18	243	6	250	7	190	6	65100	8
ST01600b	6400	9	23.7	7	5770	8	241	7	251	10	196	7	67300	4
ST01600c	7570	14	23.6	3	6190	13	259	6	258	5	203	3	67900	5
KR01600a	8260	6	26.3	3	6600	7	264	3	162	6	701	31	70200	5
KR01600b	8270	7	26.3	3	6690	5	248	1	153	6	679	46	70800	6
KR01600c	8170	10	27.7	2	7330	3	237	3	147	6	854	19	70400	5
BE01600a	2860	16	23.0	9	6610	13	294	10	198	4	113	9	53000	5
BE01600b	2920	19	24.7	6	6680	10	266	9	169	3	111	10	48800	5
BE01600c	2860	13	25.4	4	7230	16	300	12	192	12	119	4	54800	7
BO01600a	5520	9	22.8	8	6840	26	320	5	191	6	133	7	55000	6
BO01600b	5720	10	24.0	6	6210	10	300	4	178	9	140	5	57500	4
BO01600c	4780	7	31.8	7	5560	15	235	5	175	8	173	8	55400	7

Table S6 (continued).

	Co	RSD (%)	Ni	RSD (%)	Cu	RSD (%)	Zn	RSD (%)	Rb	RSD (%)	Sr	RSD (%)	Y	RSD (%)
BSO2600a	655	22	270	40	71.6	14	5760	22	150	6	172	14	22.4	15
BSO2600b	415	10	220	38	60.0	14	5050	21	152	10	159	8	22.7	8
BSO2600c	770	41	309	29	68.0	10	5470	25	170	14	156	9	32.0	35
BS01900a	81.2	19	399	23	44.8	20	4130	11	126	16	199	16	27.1	11
BS01900b	129	13	358	19	65.5	30	5770	31	164	35	278	35	28.7	15
BS01900c	98.0	16	660	29	50.6	10	4650	16	132	9	230	8	37.4	45
DM01600a	93.8	48	205	39	26.4	29	669	40	178	5	82.3	7	25.9	16
DM01600b	96.5	28	227	39	32.0	27	401	28	172	5	81.8	6	31.1	7
DM01600c	109	16	215	23	27.2	26	246	20	175	5	82.5	9	30.0	17
DN01600a	144	24	126	26	42.5	7	473	32	176	5	96.1	13	25.3	9
DN01600b	108	19	119	33	34.8	8	287	29	181	4	98.1	10	25.6	7
DN01600c	173	24	104	32	41.7	14	245	8	178	4	103	7	26.9	9
DN02600a	121	26	112	32	29.2	8	174	33	201	9	180	18	26.2	14
DN02600b	140	19	112	8	31.8	19	159	13	211	9	160	20	26.8	9
DN02600c	186	22	134	37	36.1	28	205	29	201	7	196	16	24.9	14
RU01600a	111	34	117	30	71.5	17	508	19	244	9	125	13	19.7	12
RU01600b	50.7	44	90.5	15	64.8	5	348	11	232	6	122	6	21.4	11
RU01600c	103	29	96.0	8	63.3	19	610	24	252	6	116	7	19.3	12
ST01600a	171	14	203	38	76.7	12	551	11	240	8	120	8	19.4	11
ST01600b	234	14	199	43	78.9	7	490	10	247	8	123	12	19.1	18
ST01600c	236	13	165	15	80.3	9	794	24	250	6	120	7	22.2	13
KR01600a	310	9	128	24	52.9	8	352	18	240	2	146	3	21.0	11
KR01600b	155	14	95.3	49	41.8	16	317	21	223	8	139	7	20.6	8
KR01600c	27.3	17	82.5	15	30.1	6	234	7	208	3	136	4	23.8	15
BE01600a	125	25	163	42	43.6	11	428	10	263	6	81.9	5	24.3	10
BE01600b	70.5	57	118	34	39.6	12	405	26	251	7	89.0	9	29.0	18
BE01600c	326	48	110	43	47.9	27	452	25	267	10	89.3	10	27.5	11
BO01600a	209	16	131	25	45.0	22	531	13	289	11	94.6	9	12.1	6
BO01600b	155	27	146	26	40.5	20	584	8	291	5	99.3	7	15.0	31
BO01600c	120	47	104	54	33.3	16	490	17	375	2	108	5	12.1	10

Table S6 (continued).

	Zr	RSD (%)	Nb	RSD (%)	Sn	RSD (%)	Sb	RSD (%)	Cs	RSD (%)	Ba	RSD (%)	La	RSD (%)
BSO2600a	88.2	17	16.1	49	5.38	19	3.83	41	10.5	15	1350	17	34.5	9
BSO2600b	95.5	35	10.6	20	4.33	24	2.43	58	8.80	10	1240	18	30.1	13
BSO2600c	80.0	11	18.2	52	9.54	47	2.56	43	10.8	14	1260	14	33.6	16
BS01900a	70.9	11	17.1	46	6.95	31	4.62	33	14.1	9	440	12	26.6	7
BS01900b	113	41	15.6	55	14.4	87	7.84	65	21.3	22	702	45	34.7	48
BS01900c	99.3	25	10.9	22	7.99	34	14.6	86	20.3	19	561	21	21.7	6
DM01600a	138	22	14.4	7	5.81	25	1.34	24	21.5	7	462	10	37.4	29
DM01600b	231	20	17.0	27	4.84	13	1.03	9	22.2	8	459	3	31.7	10
DM01600c	105	7	15.4	19	4.75	11	0.920	22	23.9	9	435	5	41.7	10
DN01600a	96.8	15	12.5	8	6.88	28	1.89	23	21.5	10	480	11	28.6	6
DN01600b	100	16	12.6	8	4.55	5	1.45	17	20.1	3	506	7	30.0	11
DN01600c	114	23	12.2	12	4.54	10	1.09	18	20.5	5	633	15	31.3	11
DN02600a	94.9	9	18.4	11	4.26	15	4.17	74	16.0	13	446	12	48.4	16
DN02600b	96.7	27	18.6	19	4.93	27	3.14	29	17.3	8	429	5	46.5	17
DN02600c	104	13	20.4	18	4.53	16	6.83	28	16.2	7	463	10	43.2	8
RU01600a	118	7	24.4	11	6.82	22	3.36	21	20.1	5	763	11	46.2	11
RU01600b	147	16	23.0	7	4.46	10	2.34	31	20.0	7	733	14	51.2	8
RU01600c	132	10	25.3	5	6.12	6	2.36	13	21.9	7	862	7	47.1	18
ST01600a	105	17	20.5	15	5.61	18	3.31	13	21.3	6	897	8	46.1	12
ST01600b	108	13	19.4	12	5.64	9	3.07	14	21.7	9	919	11	43.0	15
ST01600c	141	31	19.8	7	9.97	22	4.09	12	23.1	9	1040	5	46.0	7
KR01600a	117	4	18.7	5	4.82	9	1.57	14	18.3	5	1330	1	53.5	8
KR01600b	116	11	19.2	4	4.35	8	1.50	16	17.2	7	1170	6	53.7	9
KR01600c	129	16	20.0	3	3.85	7	1.11	14	15.9	3	699	5	57.0	4
BE01600a	104	17	24.1	3	10.6	16	2.18	31	21.4	6	932	10	55.6	9
BE01600b	158	12	21.9	6	6.05	22	1.54	39	19.9	10	820	12	62.3	8
BE01600c	122	24	23.4	10	6.35	11	1.63	27	22.2	11	882	15	61.1	7
BO01600a	102	14	19.2	13	6.39	23	2.57	32	21.2	14	966	5	32.2	14
BO01600b	138	18	19.0	11	6.07	15	1.75	14	20.9	11	1220	5	31.6	7
BO01600c	109	42	30.3	9	6.14	18	2.75	43	19.4	8	1560	13	35.7	12

Table S6 (continued).

	Ce	RSD (%)	Pr	RSD (%)	Nd	RSD (%)	Sm	RSD (%)	Eu	RSD (%)	Gd	RSD (%)	Tb	RSD (%)
BSO2600a	79.9	21	10.2	32	35.0	10	7.40	11	1.57	18	6.30	19	0.861	22
BSO2600b	72.7	14	7.65	13	29.6	12	6.85	17	1.53	16	5.67	13	0.817	13
BSO2600c	136	27	8.70	18	38.3	26	8.56	25	1.84	20	7.29	33	1.01	25
BS01900a	65.4	5	7.23	4	21.6	9	6.35	7	1.21	12	3.82	7	0.607	15
BS01900b	78.3	40	8.47	41	31.5	41	7.12	24	1.24	20	5.00	16	0.811	53
BS01900c	57.4	15	6.10	15	23.5	15	6.41	21	1.48	23	5.42	17	0.657	22
DM01600a	82.7	11	8.36	20	30.5	16	6.03	16	1.25	9	4.55	9	0.640	10
DM01600b	82.8	25	8.66	9	30.2	15	6.02	7	1.31	14	4.80	14	0.671	16
DM01600c	90.6	9	9.49	10	34.6	8	5.63	16	1.31	17	4.71	23	0.680	21
DN01600a	70.6	9	7.93	11	29.8	11	6.24	12	1.41	11	5.67	5	0.790	17
DN01600b	68.9	7	7.89	11	29.6	13	6.07	12	1.45	12	4.86	14	0.742	19
DN01600c	75.8	14	8.54	10	29.6	13	5.95	13	1.37	10	4.90	12	0.745	11
DN02600a	102	20	10.1	14	40.1	18	9.04	17	2.00	15	7.69	17	1.16	25
DN02600b	99.4	12	11.2	18	40.5	14	8.77	20	1.76	14	6.90	21	1.06	12
DN02600c	99.6	15	11.2	16	38.3	12	8.58	16	1.74	13	6.54	12	1.10	24
RU01600a	103	10	11.0	14	37.5	8	8.10	8	1.65	8	5.93	7	0.899	8
RU01600b	103	7	11.3	8	41.0	10	8.41	8	1.71	8	6.18	11	0.917	6
RU01600c	98.2	15	9.54	12	33.5	11	6.72	9	1.57	11	5.33	14	0.831	21
ST01600a	94.7	8	11.5	15	38.9	14	7.83	16	1.54	9	5.44	12	0.835	15
ST01600b	96.5	17	9.93	19	36.1	21	7.13	13	1.51	14	5.29	15	0.826	12
ST01600c	98.3	15	10.7	9	39.6	15	7.93	14	1.76	15	6.02	9	0.845	10
KR01600a	105	11	11.8	9	46.8	22	8.34	9	1.72	8	6.17	10	0.863	8
KR01600b	103	7	11.3	8	40.7	7	8.32	6	1.64	6	6.12	8	0.924	7
KR01600c	110	5	12.1	5	44.3	6	8.67	7	1.77	8	6.82	9	0.981	20
BE01600a	149	7	17.1	8	65.4	7	14.2	2	2.96	5	9.53	6	1.39	11
BE01600b	147	10	17.8	11	70.3	9	15.5	9	3.23	5	10.2	11	1.53	12
BE01600c	156	8	18.1	5	70.4	2	15.8	8	3.38	7	10.8	13	1.86	21
BO01600a	65.0	13	6.41	13	23.1	16	4.39	9	0.913	17	3.44	27	0.594	33
BO01600b	58.1	6	6.37	8	21.9	8	4.08	6	0.920	4	3.07	11	0.453	9
BO01600c	69.0	16	7.50	11	24.4	9	4.31	10	0.918	10	3.14	10	0.461	7

Table S6 (continued).

	Dy	RSD (%)	Ho	RSD (%)	Er	RSD (%)	Tm	RSD (%)	Yb	RSD (%)	Lu	RSD (%)	Hf	RSD (%)
BSO2600a	4.88	17	1.01	21	2.87	20	0.402	16	2.51	13	0.365	14	3.03	21
BSO2600b	4.66	12	0.925	6	2.46	8	0.329	7	2.32	10	0.346	16	4.27	16
BSO2600c	5.77	28	1.17	28	3.13	25	0.471	35	2.99	36	0.410	24	3.47	17
BS01900a	3.46	13	1.00	11	2.22	11	0.301	25	2.35	22	0.306	19	2.04	34
BS01900b	4.34	16	0.664	20	1.81	25	0.261	18	1.81	24	0.248	15	2.50	40
BS01900c	3.20	11	1.15	29	3.18	20	0.425	19	2.86	60	0.404	21	1.88	17
DM01600a	3.89	15	0.729	11	2.48	13	0.322	18	2.04	19	0.291	16	3.11	39
DM01600b	3.95	15	0.752	15	2.11	18	0.303	12	1.88	14	0.284	14	2.48	16
DM01600c	4.20	8	0.820	29	2.05	19	0.299	20	1.95	17	0.289	18	2.35	12
DN01600a	4.24	5	0.862	4	2.33	6	0.340	21	2.22	10	0.329	16	2.47	12
DN01600b	3.85	8	0.835	8	2.30	14	0.327	17	2.15	18	0.303	10	2.94	37
DN01600c	4.13	10	0.845	10	2.38	17	0.308	11	2.13	5	0.320	13	2.33	12
DN02600a	7.47	27	1.33	28	3.74	22	0.438	16	3.61	16	0.589	10	3.07	22
DN02600b	5.57	13	0.966	11	3.50	15	0.407	21	2.76	16	0.410	18	2.54	8
DN02600c	6.31	18	1.09	23	3.15	17	0.417	17	3.27	12	0.466	17	2.80	18
RU01600a	5.82	10	0.969	9	3.15	8	0.464	27	3.25	8	0.499	16	3.49	6
RU01600b	5.67	6	0.995	13	3.05	11	0.418	12	3.04	5	0.447	11	4.39	20
RU01600c	5.52	26	0.797	10	2.65	14	0.376	18	2.43	13	0.351	14	3.90	13
ST01600a	5.93	12	1.03	7	2.64	7	0.387	12	2.85	11	0.434	16	3.96	11
ST01600b	5.31	11	0.932	12	3.03	9	0.389	10	2.85	12	0.395	9	3.47	10
ST01600c	5.56	9	0.983	6	2.94	14	0.397	9	2.98	12	0.421	8	4.49	33
KR01600a	5.33	8	0.924	8	2.77	8	0.403	12	3.28	9	0.470	26	3.73	14
KR01600b	5.45	8	0.977	9	2.90	13	0.387	4	3.32	26	0.388	6	3.91	17
KR01600c	6.29	7	1.07	7	3.54	23	0.450	15	3.03	12	0.467	16	4.22	13
BE01600a	9.12	13	1.51	18	4.77	24	0.571	12	4.19	9	0.600	11	5.47	13
BE01600b	9.75	8	1.68	10	5.28	4	0.692	6	5.06	17	0.693	10	4.53	13
BE01600c	10.7	16	1.67	13	4.71	24	0.629	17	4.61	20	0.658	21	3.95	13
BO01600a	3.89	27	0.754	24	2.17	13	0.241	12	1.83	15	0.450	12	3.56	12
BO01600b	2.88	11	0.524	10	1.81	13	0.261	21	1.93	14	0.366	11	3.85	17
BO01600c	3.13	12	0.583	10	1.79	12	0.288	13	2.10	16	0.325	36	6.51	58

Table S6 (continued).

	Pb	RSD (%)	Bi	RSD (%)	Th	RSD (%)	U	RSD (%)
BSO2600a	51.4	25	3.93	64	10.7	13	4.94	31
BSO2600b	52.4	12	1.79	35	9.85	12	4.11	23
BSO2600c	61.7	45	4.36	96	11.3	22	5.42	48
BS01900a	56.8	24	12.4	82	8.01	23	7.61	26
BS01900b	49.6	25	9.09	73	8.58	30	10.5	35
BS01900c	39.6	33	2.06	43	6.48	7	8.70	33
DM01600a	41.2	15	1.18	43	9.85	12	3.46	19
DM01600b	47.4	18	1.01	35	9.87	8	3.19	7
DM01600c	47.8	8	1.22	60	9.49	13	3.04	16
DN01600a	59.9	19	2.03	25	11.7	7	7.16	22
DN01600b	51.6	16	1.28	22	10.6	5	5.36	8
DN01600c	53.6	4	1.09	21	11.1	7	5.41	11
DN02600a	41.5	14	1.57	48	12.4	6	5.52	38
DN02600b	38.8	18	1.35	27	11.8	11	5.25	50
DN02600c	39.0	17	1.12	38	12.1	5	3.20	11
RU01600a	47.1	26	0.744	37	14.2	10	6.27	7
RU01600b	35.8	15	0.608	16	14.9	10	6.13	18
RU01600c	35.5	28	0.996	25	12.4	18	5.26	18
ST01600a	44.7	8	0.686	31	12.3	12	11.2	8
ST01600b	48.4	14	1.41	70	12.1	7	10.7	11
ST01600c	47.1	7	0.959	43	12.9	11	11.6	11
KR01600a	38.5	20	0.530	28	13.5	6	3.40	8
KR01600b	37.9	23	0.485	16	13.2	5	3.27	3
KR01600c	30.5	9	0.355	10	14.7	5	3.15	6
BE01600a	72.7	13	0.958	16	16.7	14	6.26	19
BE01600b	50.9	17	0.851	38	16.2	5	4.45	6
BE01600c	48.4	12	0.665	7	14.6	11	5.03	15
BO01600a	60.4	17	0.924	20	13.9	10	4.91	10
BO01600b	60.1	16	0.796	24	14.6	5	3.53	8
BO01600c	47.5	11	0.670	28	16.2	15	4.07	34

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