



Japan Cement Association

## Certificate of Analysis

### Reference Materials for X-ray fluorescence Analysis

#### 601B

These reference materials are intended to use in the calibration of X-ray fluorescence method for chemical analysis of cement. These materials correspond to Industrial Reference Materials (IRMs) specified in JIS R 5204:2002.

#### 1. Reference values and Information values

The reference values and the information values are expressed as mass % on the basis of sample which is ignited to constant weight at around 950 degrees Celsius.

#### Reference values

(mass %)

Sample	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
No.1	17.61	5.10	2.37	59.07	1.31	9.83	0.809	1.191	0.282	1.479	0.404
No.2	20.75	5.98	2.90	65.23	1.37	2.34	0.272	0.370	0.299	0.119	0.097
No.3	19.11	4.45	2.37	63.18	2.36	5.97	0.373	0.696	0.222	0.758	0.050
No.4	20.36	5.23	2.77	66.63	0.87	2.70	0.166	0.281	0.333	0.198	0.080
No.5	24.41	3.28	3.37	64.96	1.02	1.79	0.199	0.355	0.189	0.111	0.058
No.6	23.18	3.87	4.13	64.15	0.83	2.20	0.223	0.413	0.201	0.126	0.105
No.7	26.27	2.82	3.14	63.36	0.80	2.57	0.153	0.398	0.164	0.096	0.037
No.8	26.61	2.73	3.05	63.49	0.59	2.48	0.186	0.304	0.143	0.169	0.104
No.9	24.53	7.94	2.07	58.91	2.49	—	0.328	0.320	0.370	0.110	0.081
No.10	26.50	9.47	1.83	54.60	3.22	—	0.239	0.342	0.379	0.154	0.148
No.11	26.11	8.89	1.98	55.64	2.96	—	0.311	0.337	0.399	0.283	0.181
No.12	24.75	8.75	2.14	55.78	3.13	—	0.189	0.319	1.035	0.085	0.620
No.13	28.61	11.03	1.10	50.51	4.20	—	0.348	0.291	0.449	0.055	0.112
No.14	35.03	16.05	0.24	35.85	10.21	—	0.274	0.188	0.435	0.011	0.115
No.15	14.87	2.07	7.01	75.62	0.01	0.02	0.030	0.000	0.004	0.003	0.002

#### Information values

(mass %)

	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10
SrO	0.38	0.06	0.19	0.04	0.03	0.03	0.03	0.02	0.05	0.05

	No.11	No.12	No.13	No.14	No.15
SrO	0.06	0.04	0.05	0.05	0.02

## 2. Constituent materials and Quantity

The constituent materials are shown in the following table.

Each bottle, No.1~No.14, contains approximately 20g of material. No.15 bottle contains approximately 30g of material.

Sample	Constituent materials
No.1	Portland cement, Reagent ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ , $\text{K}_2\text{SO}_4$ , $\text{NaH}_2\text{PO}_4$ , $\text{MnO}$ , $\text{SrCO}_3$ )
No.2	Portland cement
No.3	Portland cement, Reagent ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ , $\text{K}_2\text{SO}_4$ , $\text{NaH}_2\text{PO}_4$ , $\text{SrCO}_3$ )
No.4	Portland cement
No.5	Portland cement
No.6	Portland cement
No.7	Portland cement
No.8	Portland cement
No.9	Blast furnace slag cement
No.10	Blast furnace slag cement
No.11	Blast furnace slag cement
No.12	Blast furnace slag cement, Reagent ( $\text{TiO}_2$ , $\text{MnO}$ )
No.13	Blast furnace slag cement
No.14	Blast furnace slag, Reagent ( $\text{SiO}_2$ , $\text{Al}_2\text{O}_3$ , $\text{MgO}$ )
No.15	Reagent ( $\text{SiO}_2$ , $\text{Al}_2\text{O}_3$ , $\text{Fe}_2\text{O}_3$ , $\text{CaCO}_3$ )

## 3. Precautions for use

The loss on ignition of a material may change gradually. When a glass bead is prepared from an unignited material, the loss on ignition of the material must be determined.

## 4. Homogeneity

The homogeneity test was carried out for all of materials as follows.

- ① Eight portions of a sample were equivalently made using a riffle sampler. Each glass bead was made from the eight portions.
- ② The concentration of each element in a bead was analyzed by X-ray fluorescence spectrometer.
- ③ Mean value and range were calculated from the results of eight beads.
- ④ Each range was verified to achieve the reproducibility limit for each mean value in JIS R 5204.

## 5. Reference values

- (1) Reference values were determined by cooperative testing based on JCAS I-14 : 2010 "Chemical analysis method for raw materials of cement clinker".

Note : JCAS I-14 does not include a method about Sr to correct for amount of CaO and a method about Zn to correct for amount of  $\text{Al}_2\text{O}_3$ . These were corrected for the determination of reference values.

(2) Cooperative testing

The outline of the cooperative testing is shown as follows.

- ① Each laboratory tested twice at the same time. Mean values were calculated from these tests as laboratory results.
- ② The data which was judged as 5% outlier on Grubbs test specified in JIS Z 8402-2 : 1999 was excluded. In addition, the data which was empirically judged as outlier was excluded. The mean values of the laboratory results which are not excluded were assigned as reference values.

(3) Cooperating laboratories

Funabashi Technical Center, Chuken Consultant, Co., Ltd.

Omi plant, Denki Kagaku Kogyo Kabushiki Kaisha

Research & Development Laboratory, Japan Cement Association

Cement Research Institute, Production Dept., Cement Company, Mitsubishi Materials Corp.

Quality Testing Department, Taiheiyo Consultant Co., Ltd.

Technical Development Center, Cement & Construction Materials Company, Ube Industries, Ltd.

6. References

- 1) JCAS I-14 : 2010 "Chemical analysis method for raw materials of cement clinker"
- 2) JIS Z 8402-2 : 1999 「Accuracy(trueness and precision) of measurement methods and results – Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method」 (IDT ISO5725-2:1994)
- 3) JIS R 5204 : 2002 「Chemical analysis method of cement by X-ray fluorescence」

7. Other information

Additional information about 601B will be shown on our web-site ([www.jcassoc.or.jp](http://www.jcassoc.or.jp)) as needed.

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## (Appendix) The results of cooperative testing

The results of cooperative testing are shown as follows. This appendix is not a part of the certificate.

### No.1

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	17.64	—	2.37	59.04	1.29	9.81	0.785	1.211	0.286	1.543	0.400
B	17.84	5.11	2.32	59.23	1.29	9.82	0.807	1.142	0.281	1.460	0.413
C	—	—	—	—	—	—	—	—	—	—	—
D	17.40	5.15	2.43	58.63	1.38	9.96	0.814	1.182	0.285	1.450	0.407
E	17.62	—	2.38	59.43	1.25	9.93	0.775	1.177	0.277	1.459	0.400
F	17.57	5.05	2.36	59.03	1.35	9.62	0.866	1.241	0.280	1.483	0.402
Average	17.61	5.10	2.37	59.07	1.31	9.83	0.809	1.191	0.282	1.479	0.404
Max.	17.84	5.15	2.43	59.43	1.38	9.96	0.866	1.241	0.286	1.543	0.413
Min.	17.40	5.05	2.32	58.63	1.25	9.62	0.775	1.142	0.277	1.450	0.400
Range	0.44	0.10	0.11	0.80	0.13	0.34	0.091	0.099	0.009	0.093	0.013
Std. Dev.	0.158	0.050	0.040	0.296	0.052	0.134	0.0364	0.0373	0.0037	0.0378	0.0058

### No.2

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	20.82	—	2.85	65.21	1.34	2.42	0.259	0.376	0.298	0.123	0.093
B	20.69	5.95	2.96	65.17	1.35	2.22	0.292	0.375	0.333	0.120	0.101
C	—	—	—	—	—	—	—	—	—	—	—
D	—	—	—	—	—	—	—	—	—	—	—
E	20.86	—	2.90	65.64	1.38	2.45	0.247	0.347	0.291	0.118	0.097
F	20.64	6.01	2.89	64.90	1.40	2.25	0.290	0.382	0.275	0.113	0.098
Average	20.75	5.98	2.90	65.23	1.37	2.34	0.272	0.370	0.299	0.119	0.097
Max.	20.86	6.01	2.96	65.64	1.40	2.45	0.292	0.382	0.333	0.123	0.101
Min.	20.64	5.95	2.85	64.90	1.34	2.22	0.247	0.347	0.275	0.113	0.093
Range	0.22	0.06	0.11	0.74	0.06	0.23	0.045	0.035	0.058	0.010	0.008
Std. Dev.	0.104	0.042	0.045	0.306	0.028	0.117	0.0225	0.0156	0.0245	0.0042	0.0033

### No.3

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	19.23	—	2.38	62.97	2.36	6.05	0.362	0.724	0.222	0.778	0.052
B	18.94	4.45	—	63.37	2.36	5.83	0.372	0.656	0.228	0.756	0.050
C	—	—	—	—	—	—	—	—	—	—	—
D	—	—	—	—	—	—	—	—	—	—	—
E	19.08	—	2.37	63.34	2.35	6.10	0.353	0.663	0.218	0.740	0.048
F	19.20	4.45	2.37	63.05	—	5.88	0.404	0.741	0.221	0.758	0.049
Average	19.11	4.45	2.37	63.18	2.36	5.97	0.373	0.696	0.222	0.758	0.050
Max.	19.23	4.45	2.38	63.37	2.36	6.10	0.404	0.741	0.228	0.778	0.052
Min.	18.94	4.45	2.37	62.97	2.35	5.83	0.353	0.656	0.218	0.740	0.048
Range	0.29	0.00	0.01	0.40	0.01	0.27	0.051	0.085	0.010	0.038	0.004
Std. Dev.	0.132	0.000	0.006	0.202	0.006	0.130	0.0222	0.0428	0.0042	0.0156	0.0017

No.4

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	20.51	—	2.68	66.54	0.85	2.80	0.147	0.267	0.328	0.203	0.086
B	20.29	5.23	2.84	66.50	0.85	2.74	0.187	0.297	0.354	0.196	0.091
C	20.25	5.23	2.75	67.05	0.88	2.60	0.159	0.269	0.332	0.201	0.091
D	—	—	—	—	—	—	—	—	—	—	—
E	—	—	—	—	—	—	—	—	—	—	—
F	20.38	5.23	2.79	66.42	0.88	2.67	0.172	0.289	0.316	0.190	0.092
Average	20.36	5.23	2.77	66.63	0.87	2.70	0.166	0.281	0.333	0.198	0.090
Max.	20.51	5.23	2.84	67.05	0.88	2.80	0.187	0.297	0.354	0.203	0.092
Min.	20.25	5.23	2.68	66.42	0.85	2.60	0.147	0.267	0.316	0.190	0.086
Range	0.26	0.00	0.16	0.63	0.03	0.20	0.040	0.030	0.038	0.013	0.006
Std. Dev.	0.115	0.000	0.068	0.286	0.017	0.087	0.0172	0.0148	0.0159	0.0058	0.0027

No.5

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	—	—	—	—	—	—	—	—	—	—	—
B	24.40	3.34	3.36	65.03	1.01	1.81	0.222	0.354	0.207	0.112	0.062
C	24.25	3.27	3.39	65.23	1.04	1.70	0.194	0.348	0.194	0.116	0.056
D	24.31	3.21	—	64.66	1.03	1.94	0.197	0.371	0.181	0.109	0.059
E	24.68	—	3.35	65.12	1.00	1.86	0.176	0.337	0.179	0.112	0.056
F	24.43	3.30	3.38	64.74	1.03	1.66	0.204	0.365	0.186	0.105	0.057
Average	24.41	3.28	3.37	64.96	1.02	1.79	0.199	0.355	0.189	0.111	0.058
Max.	24.68	3.34	3.39	65.23	1.04	1.94	0.222	0.371	0.207	0.116	0.062
Min.	24.25	3.21	3.35	64.66	1.00	1.66	0.176	0.337	0.179	0.105	0.056
Range	0.43	0.13	0.04	0.57	0.04	0.28	0.046	0.034	0.028	0.011	0.006
Std. Dev.	0.165	0.055	0.018	0.246	0.016	0.115	0.0167	0.0135	0.0114	0.0041	0.0025

No.6

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	—	—	—	—	—	—	—	—	—	—	—
B	23.11	3.88	4.23	64.08	0.82	2.25	0.225	0.391	0.235	0.124	0.106
C	23.15	3.95	4.08	64.56	0.83	2.02	0.215	0.395	0.194	0.131	0.104
D	—	3.73	4.11	63.76	0.82	2.40	0.221	0.409	0.185	0.122	0.103
E	—	—	—	—	—	—	—	—	—	—	—
F	23.27	3.91	4.11	64.18	0.86	2.14	0.229	0.457	0.188	0.127	0.106
Average	23.18	3.87	4.13	64.15	0.83	2.20	0.223	0.413	0.201	0.126	0.105
Max.	23.27	3.95	4.23	64.56	0.86	2.40	0.229	0.457	0.235	0.131	0.106
Min.	23.11	3.73	4.08	63.76	0.82	2.02	0.215	0.391	0.185	0.122	0.103
Range	0.16	0.22	0.15	0.80	0.04	0.38	0.014	0.066	0.050	0.009	0.003
Std. Dev.	0.083	0.096	0.067	0.330	0.019	0.162	0.0060	0.0303	0.0233	0.0039	0.0015

No.7

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	26.42	—	3.04	63.33	0.77	2.61	0.128	0.393	0.168	0.101	0.036
B	26.16	2.85	3.15	63.53	0.79	2.48	0.175	0.397	0.177	0.094	0.040
C	—	—	—	—	—	—	—	—	—	—	—
D	26.24	2.83	3.24	62.89	0.83	2.70	0.151	0.408	0.160	0.093	0.039
E	26.36	—	3.13	63.69	0.77	2.65	0.137	0.375	0.156	0.096	0.035
F	26.16	2.77	3.12	63.36	0.83	2.43	0.172	0.416	0.160	0.097	0.036
Average	26.27	2.82	3.14	63.36	0.80	2.57	0.153	0.398	0.164	0.096	0.037
Max.	26.42	2.85	3.24	63.69	0.83	2.70	0.175	0.416	0.177	0.101	0.040
Min.	26.16	2.77	3.04	62.89	0.77	2.43	0.128	0.375	0.156	0.093	0.035
Range	0.26	0.08	0.20	0.80	0.06	0.27	0.047	0.041	0.021	0.008	0.005
Std. Dev.	0.118	0.042	0.072	0.300	0.030	0.115	0.0208	0.0156	0.0084	0.0031	0.0022

No.8

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	—	—	—	—	—	—	—	—	—	—	—
B	26.37	2.77	3.03	63.63	0.58	2.48	0.205	0.307	0.175	0.167	0.108
C	26.68	2.71	3.05	63.65	0.60	2.36	0.176	0.291	0.144	0.174	0.102
D	26.83	2.75	—	62.91	0.61	2.64	0.194	0.341	0.131	0.166	0.105
E	26.73	—	3.05	63.86	0.56	2.58	0.163	0.274	0.131	0.169	0.102
F	26.44	2.67	3.05	63.39	0.62	2.33	0.192	0.308	0.134	0.171	0.103
Average	26.61	2.73	3.05	63.49	0.59	2.48	0.186	0.304	0.143	0.169	0.104
Max.	26.83	2.77	3.05	63.86	0.62	2.64	0.205	0.341	0.175	0.174	0.108
Min.	26.37	2.67	3.03	62.91	0.56	2.33	0.163	0.274	0.131	0.166	0.102
Range	0.46	0.10	0.02	0.95	0.06	0.31	0.042	0.067	0.044	0.008	0.006
Std. Dev.	0.196	0.044	0.010	0.363	0.024	0.135	0.0165	0.0248	0.0187	0.0032	0.0025

No.9

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	24.62	—	2.07	58.85	2.43	—	0.304	0.322	0.375	0.115	0.071
B	24.46	7.94	2.00	58.94	2.50	—	0.346	0.313	0.387	0.109	0.087
C	—	—	—	—	—	—	—	—	—	—	—
D	24.67	8.00	2.18	58.91	2.54	—	0.330	0.322	0.362	0.105	0.082
E	24.37	—	2.04	—	2.41	—	0.310	0.312	0.366	0.108	0.082
F	24.51	7.89	2.06	58.95	2.59	—	0.352	0.331	0.362	0.111	0.083
Average	24.53	7.94	2.07	58.91	2.49	—	0.328	0.320	0.370	0.110	0.081
Max.	24.67	8.00	2.18	58.95	2.59	—	0.352	0.331	0.387	0.115	0.087
Min.	24.37	7.89	2.00	58.85	2.41	—	0.304	0.312	0.362	0.105	0.071
Range	0.30	0.11	0.18	0.10	0.18	—	0.048	0.019	0.025	0.010	0.016
Std. Dev.	0.121	0.055	0.067	0.045	0.075	—	0.0212	0.0078	0.0107	0.0037	0.0060

No.10

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	26.48	—	1.82	54.36	3.07	—	0.234	0.349	0.381	0.158	0.142
B	26.41	9.45	1.85	54.68	3.28	—	0.247	0.342	—	0.153	0.152
C	—	—	—	—	—	—	—	—	—	—	—
D	—	—	—	—	—	—	—	—	—	—	—
E	26.49	—	1.80	54.87	3.13	—	0.211	0.318	0.378	0.152	0.147
F	26.61	9.48	1.83	54.50	3.38	—	0.262	0.358	0.377	0.152	0.150
Average	26.50	9.47	1.83	54.60	3.22	—	0.239	0.342	0.379	0.154	0.148
Max.	26.61	9.48	1.85	54.87	3.38	—	0.262	0.358	0.381	0.158	0.152
Min.	26.41	9.45	1.80	54.36	3.07	—	0.211	0.318	0.377	0.152	0.142
Range	0.20	0.03	0.05	0.51	0.31	—	0.051	0.040	0.004	0.006	0.010
Std. Dev.	0.083	0.021	0.021	0.221	0.141	—	0.0216	0.0171	0.0021	0.0029	0.0043

No.11

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	26.20	—	1.96	55.48	2.84	—	0.288	0.338	0.398	0.283	0.177
B	25.83	8.89	2.01	55.82	3.01	—	0.310	0.331	—	0.283	0.190
C	26.11	8.92	1.95	55.91	2.89	—	0.305	0.321	0.414	0.285	0.170
D	—	—	—	—	—	—	—	—	—	—	—
E	—	—	—	—	—	—	—	—	—	—	—
F	26.30	8.86	2.00	55.53	3.09	—	0.339	0.358	0.386	0.282	0.185
Average	26.11	8.89	1.98	55.64	2.96	—	0.311	0.337	0.399	0.283	0.181
Max.	26.30	8.92	2.01	55.91	3.09	—	0.339	0.358	0.414	0.285	0.190
Min.	25.83	8.86	1.95	55.48	2.84	—	0.288	0.321	0.386	0.282	0.170
Range	0.47	0.06	0.06	0.43	0.25	—	0.051	0.037	0.028	0.003	0.020
Std. Dev.	0.202	0.030	0.029	0.192	0.114	—	0.0212	0.0156	0.0140	0.0013	0.0088

No.12

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	—	—	—	—	—	—	—	—	—	—	—
B	24.64	8.81	2.16	55.29	3.16	—	0.175	0.316	1.026	0.086	0.632
C	24.89	8.70	2.07	56.07	3.10	—	0.190	0.310	1.063	0.087	0.614
D	24.64	8.83	2.21	56.10	3.13	—	0.201	0.330	1.020	0.081	0.619
E	—	—	—	—	—	—	—	—	—	—	—
F	24.83	8.65	2.11	55.64	—	—	—	—	1.032	0.084	0.616
Average	24.75	8.75	2.14	55.78	3.13	—	0.189	0.319	1.035	0.085	0.620
Max.	24.89	8.83	2.21	56.10	3.16	—	0.201	0.330	1.063	0.087	0.632
Min.	24.64	8.65	2.07	55.29	3.10	—	0.175	0.310	1.020	0.081	0.614
Range	0.25	0.18	0.14	0.81	0.06	—	0.026	0.020	0.043	0.006	0.018
Std. Dev.	0.129	0.087	0.081	0.386	0.030	—	0.0131	0.0103	0.0191	0.0026	0.0081

No.13

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	—	—	—	—	—	—	—	—	—	—	—
B	28.35	11.08	1.12	50.21	4.19	—	0.357	0.293		0.058	0.113
C	28.58	11.00	1.08	50.89	4.13	—	0.327	0.272	0.470	0.050	0.110
D	28.75	11.10	1.09	50.49	4.17	—	0.345	0.302	0.434	0.053	0.111
E	—	—	—	—	—	—	—	—	—	—	—
F	28.75	10.92	1.12	50.44	4.31	—	0.361	0.296	0.442	0.059	0.113
Average	28.61	11.03	1.10	50.51	4.20	—	0.348	0.291	0.449	0.055	0.112
Max.	28.75	11.10	1.12	50.89	4.31	—	0.361	0.302	0.470	0.059	0.113
Min.	28.35	10.92	1.08	50.21	4.13	—	0.327	0.272	0.434	0.050	0.110
Range	0.40	0.18	0.04	0.68	0.18	—	0.034	0.030	0.036	0.009	0.003
Std. Dev.	0.189	0.082	0.021	0.283	0.077	—	0.0153	0.0130	0.0189	0.0042	0.0015

No.14

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	—	—	—	—	—	—	—	—	—	—	—
B	34.93	16.04	0.22	35.89	10.31	—	0.272	0.192	0.481	0.010	0.120
C	34.76	16.04	0.25	35.92	10.31	—	0.266	0.183	0.449	0.011	0.113
D	35.22	15.94	0.26	35.91	10.24	—	0.295	0.200	0.404	0.009	0.115
E	35.08	—	0.23	35.82	9.99	—	0.261	0.175	0.425	0.012	0.114
F	35.16	16.17	0.25	35.73	—	—	—	—	0.414	0.012	0.115
Average	35.03	16.05	0.24	35.85	10.21	—	0.274	0.188	0.435	0.011	0.115
Max.	35.22	16.17	0.26	35.92	10.31	—	0.295	0.200	0.481	0.012	0.120
Min.	34.76	15.94	0.22	35.73	9.99	—	0.261	0.175	0.404	0.009	0.113
Range	0.46	0.23	0.04	0.19	0.32	—	0.034	0.025	0.077	0.003	0.007
Std. Dev.	0.186	0.094	0.016	0.080	0.152	—	0.0150	0.0108	0.0309	0.0013	0.0027

No.15

Laboratory	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	SO <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
A	15.03	—	6.98	75.69	0.00	—	0.029	0.000	0.002	0.003	0.002
B	14.74	2.10	7.15	75.59	0.02	0.03	0.037	0.000			0.000
C	14.77	2.02	6.92	75.48	0.00	0.00	0.025	0.000	0.005	0.003	0.002
D	—	—	—	—	—	—	—	—	—	—	—
E	—	—	—	—	—	—	—	—	—	—	—
F	14.93	2.10	6.98	75.70	—	0.02	—	—	0.005	0.002	0.002
Average	14.87	2.07	7.01	75.62	0.01	0.02	0.030	0.000	0.004	0.003	0.002
Max.	15.03	2.10	7.15	75.70	0.02	0.03	0.037	0.000	0.005	0.003	0.002
Min.	14.74	2.02	6.92	75.48	0.00	0.00	0.025	0.000	0.002	0.002	0.000
Range	0.29	0.08	0.23	0.22	0.02	0.03	0.012	0.000	0.003	0.001	0.002
Std. Dev.	0.137	0.046	0.099	0.103	0.012	0.015	0.0061	0.0000	0.0017	0.0006	0.0010