

Appendix B: Analytical quality control of major and trace element data.

Table B.1 Major element data of several rock standards.

Element (wt.%)	JGB-1 #1	JGB-1 #2	Mean	Ref. value ¹	JB-3 #1	JB-3 #2	Mean	Ref. value ¹
SiO ₂	43.59	43.97	43.78	43.44	50.17	50.63	50.40	51.04
Al ₂ O ₃	17.71	17.41	17.56	17.66	17.1	16.89	17.00	16.89
Fe ₂ O ₃	15.38	15.07	15.23	15.16	11.82	11.64	11.73	11.88
MnO	0.19	0.19	0.19	0.17	0.17	0.17	0.17	0.16
MgO	7.71	7.72	7.72	7.83	5.01	5.05	5.03	5.2
CaO	11.79	11.72	11.76	11.98	9.57	9.60	9.59	9.86
Na ₂ O	1.25	1.30	1.28	1.23	3.11	2.77	2.94	2.82
K ₂ O	0.23	0.23	0.23	0.24	0.76	0.75	0.76	0.78
TiO ₂	1.62	1.61	1.62	1.62	1.42	1.43	1.43	1.45
P ₂ O ₅	0.06	0.05	0.06	0.05	0.28	0.29	0.29	0.29

Element (wt.%)	JB-2 #1	JB-2 #2	Mean	Ref. value ¹	JA-3 #1	JA-3 #2	Mean	Ref. value ¹
SiO ₂	53.46	54.09	53.78	53.2	61.92	61.71	61.82	62.26
Al ₂ O ₃	14.83	14.68	14.76	14.67	15.75	15.20	15.48	15.57
Fe ₂ O ₃	14.45	14.23	14.34	14.34	6.56	6.33	6.45	6.59
MnO	0.21	0.22	0.22	0.2	0.1	0.10	0.10	0.106
MgO	4.53	4.57	4.55	4.66	3.66	3.58	3.62	3.65
CaO	9.83	9.78	9.81	9.89	6.27	6.11	6.19	6.28
Na ₂ O	2.08	2.11	2.10	2.03	3.1	3.15	3.13	3.17
K ₂ O	0.42	0.41	0.42	0.42	1.39	1.37	1.38	1.41
TiO ₂	1.19	1.19	1.19	1.19	0.7	0.68	0.69	0.68
P ₂ O ₅	0.09	0.09	0.09	0.1	0.11	0.11	0.11	0.11

Element (wt.%)	JG-3 #1	JG-3 #2	Mean	Ref. value ¹	JG-2 #1	JG-2 #2	Mean	Ref. value ¹
SiO ₂	66.4	67.19	66.80	67.1	76.61	77.76	77.19	76.95
Al ₂ O ₃	15.47	15.25	15.36	15.52	12.43	12.32	12.38	12.41
Fe ₂ O ₃	3.7	3.66	3.68	3.73	0.92	0.90	0.91	0.92
MnO	0.07	0.07	0.07	0.072	0.02	0.02	0.02	0.015
MgO	1.77	1.76	1.77	1.79	0.05	0.03	0.04	0.04
CaO	3.74	3.74	3.74	3.76	0.7	0.71	0.71	0.8
Na ₂ O	4.01	4.15	4.08	4.03	3.61	3.67	3.64	3.55
K ₂ O	2.61	2.62	2.62	2.63	4.68	4.71	4.70	4.72
TiO ₂	0.48	0.48	0.48	0.48	0.05	0.04	0.05	0.04
P ₂ O ₅	0.13	0.12	0.13	0.12	0.01	0.00	0.01	0.002

¹Working values from Govindaraju (1994)

Table B.2 Trace element data of reference material BIR-1. CL = confidence level.

# Analysis/ Element (ppm)	#1	#2	#3	#4	#5	Mean	Uncertainty (95% CL)	Ref. Value ¹	Uncertainty (95% CL)
Li	3.23	3.43	3.22	3.39	3.35	3.32	0.19	3.203	0.069
Sc	44.3	42.8	42.7	44.2	43.7	43.5	1.5	43.21	0.59
V	316	320	325	321	325	322	8	320.6	2.9
Cr	389	377	373	373	375	378	13	392.9	3.9
Co	51.7	52.0	51.5	52.8	52.4	52.1	1.1	52.22	0.57
Ni	161	171	166	170	170	168	8	168.9	1.9
Cu	114	115	119	120	121	118	6	120.7	1.6
Zn	68.3	69.8	79.7	67.3	69.5	70.9	10.0	70.4	1.1
Ga	15.1	15.2	15.9	15.6	15.6	15.5	0.6	15.46	0.23
Rb	0.21	0.20	0.35	0.29	0.26	0.26	0.12	0.21	0.0081
Sr	110	106	106	113	112	109	6	108.6	0.7
Y	15.5	15.1	14.9	15.4	15.5	15.3	0.5	15.6	0.17
Zr	13.9	13.8	14.4	14.6	14.6	14.3	0.8	14.8	0.22
Nb	0.538	0.514	0.543	0.542	0.539	0.535	0.024	0.553	0.014
Cs	0.007	0.007	0.031	0.017	0.018	0.016	0.020	0.00646	0.00072
Ba	6.13	5.92	6.78	6.82	6.81	6.49	0.87	6.75	0.13
La	0.612	0.592	0.621	0.614	0.621	0.612	0.024	0.627	0.012
Ce	1.90	1.88	1.87	1.90	1.90	1.89	0.03	1.92	0.023
Pr	0.378	0.377	0.386	0.379	0.386	0.381	0.009	0.3723	0.0047
Nd	2.44	2.42	2.51	2.47	2.50	2.47	0.08	2.397	0.043
Sm	1.14	1.12	1.24	1.19	1.19	1.18	0.10	1.113	0.018
Eu	0.534	0.528	0.562	0.554	0.557	0.547	0.030	0.5201	0.0047
Gd	1.82	1.80	1.92	1.87	1.86	1.85	0.09	1.809	0.021
Tb	0.369	0.357	0.375	0.372	0.374	0.370	0.015	0.3623	0.005
Dy	2.64	2.55	2.68	2.65	2.65	2.63	0.09	2.544	0.028
Ho	0.585	0.565	0.591	0.585	0.590	0.583	0.021	0.5718	0.0047
Er	1.67	1.61	1.68	1.69	1.68	1.67	0.06	1.68	0.015
Tm	0.254	0.244	0.265	0.259	0.260	0.256	0.016	0.2558	0.004
Yb	1.68	1.61	1.72	1.70	1.71	1.68	0.09	1.631	0.015
Lu	0.253	0.242	0.257	0.256	0.255	0.252	0.012	0.2484	0.0032
Hf	0.581	0.547	0.622	0.583	0.584	0.584	0.053	0.5822	0.0088
Ta	0.052	0.037	0.057	0.055	0.051	0.050	0.016	0.0414	0.002
Pb	3.00	2.88	3.29	3.39	3.01	3.11	0.43	3.037	0.049
Th	0.033	0.030	0.058	0.046	0.045	0.042	0.023	0.0328	0.0015
U	0.013	0.012	0.035	0.025	0.026	0.022	0.019	0.01051	0.00041

¹GeoReM reference values (Jochum et al., 2016)

Table B.3 Trace element data of reference material BHVO-2. CL = confidence level.

# Analysis/ Element (ppm)	#1	#2	#3	#4	#5	#6	Mean	Uncertainty (95% CL)	Ref. Value ¹	Uncertainty (95% CL)
Li	4.46	4.78	4.48	4.50	4.55	4.59	4.56	0.24	4.5	0.085
Sc	31.8	31.3	31.5	31.1	31.0	33.1	31.6	1.6	31.83	0.34
V	316	321	325	314	319	326	320	9	318.2	2.3
Cr	292	288	283	282	283	294	287	10	287.2	3.1
Co	44.4	44.6	43.8	44.2	44.2	46.4	44.6	1.9	44.89	0.32
Ni	120	120	115	117	117	121	118	5	119.8	1.2
Cu	127	128	126	129	129	130	128	3	129.3	1.4
Zn	104	107	109	101	100	104	104	7	103.9	1
Ga	21.2	21.4	22.0	21.3	21.2	22.2	21.5	0.9	21.37	0.2
Rb	9.17	9.15	9.12	9.14	9.11	9.28	9.16	0.13	9.261	0.096
Sr	396	390	388	398	402	400	396	11	394.1	1.7
Y	25.6	25.2	24.7	25.2	25.2	26.1	25.4	0.9	25.91	0.28
Zr	174	172	165	165	163	177	169	11	171.2	1.3
Nb	17.4	17.6	17.7	17.5	17.5	17.8	17.6	0.3	18.1	0.2
Cs	0.105	0.101	0.124	0.112	0.113	0.116	0.112	0.016	0.0996	0.0022
Ba	133	129	135	134	135	140	134	8	130.9	1
La	15.3	15.4	15.2	15.0	15.0	16.0	15.3	0.7	15.2	0.08
Ce	37.9	38.1	37.2	36.8	36.7	38.7	37.6	1.6	37.53	0.19
Pr	5.43	5.43	5.28	5.25	5.24	5.49	5.35	0.21	5.339	0.028
Nd	25.1	25.0	24.7	24.5	24.4	25.7	24.9	1.0	24.27	0.25
Sm	6.26	6.22	6.22	6.16	6.15	6.36	6.23	0.16	6.023	0.057
Eu	2.09	2.08	2.10	2.09	2.10	2.17	2.11	0.06	2.043	0.012
Gd	6.28	6.19	6.20	6.10	6.08	6.41	6.21	0.25	6.207	0.038
Tb	0.958	0.940	0.952	0.948	0.949	0.970	0.953	0.021	0.9392	0.006
Dy	5.40	5.30	5.37	5.34	5.31	5.50	5.37	0.15	5.28	0.028
Ho	1.00	0.98	0.99	0.98	0.99	1.01	0.99	0.02	0.9887	0.0053
Er	2.48	2.43	2.49	2.49	2.46	2.52	2.48	0.06	2.511	0.014
Tm	0.334	0.323	0.342	0.342	0.341	0.335	0.336	0.015	0.3349	0.0031
Yb	2.03	1.98	2.05	2.06	2.04	2.06	2.04	0.06	1.994	0.027
Lu	0.284	0.273	0.288	0.287	0.289	0.296	0.286	0.015	0.2754	0.0024
Hf	4.35	4.14	4.28	4.09	4.07	4.42	4.22	0.29	4.47	0.025
Ta	1.03	1.06	1.09	1.08	1.08	1.11	1.07	0.05	1.154	0.019
Pb	1.60	1.57	1.59	1.55	1.53	1.57	1.57	0.05	1.653	0.038
Th	1.21	1.14	1.21	1.19	1.19	1.22	1.19	0.06	1.224	0.016
U	0.426	0.392	0.423	0.400	0.403	0.438	0.414	0.036	0.412	0.035

¹GeoReM reference values (Jochum et al., 2016)

Table B.4 Precision of trace element data for separate sample digests (Dup1 and Dup2).

Element (ppm)	M81-217-4 Dup1	M81-217-4 Dup2	Diff. (%)	M81-223-1 Dup1	M81-223-1 Dup2	Diff. (%)	M81-229-12 Dup1	M81-229-12 Dup2	Diff. (%)	M81-234-4 Dup1	M81-234-4 Dup2	Diff. (%)
Li	22.6	22.4	0.6	9.25	9.25	0.0	49.3	49.4	0.1	17.4	17.3	0.5
Sc	53.1	53.1	0.1	31.0	31.5	1.5	37.8	38.0	0.3	57.3	57.5	0.3
V	362	362	0.1	198	202	2.2	346	346	0.1	411	409	0.5
Cr	250	247	1.2	257	260	1.2	732	730	0.3	165	165	0.2
Co	56.1	56.8	1.3	26.6	26.9	1.0	45.2	44.9	0.7	50.7	51.0	0.6
Ni	120	120	0.4	124	127	2.6	220	220	0.2	87.6	86.5	1.4
Cu	144	143	0.4	88.3	89.8	1.7	95.1	96.1	1.1	234	235	0.6
Zn	91.2	88.6	2.9	42.0	44.2	5.2	115	119	3.4	161	165	2.6
Ga	16.6	16.6	0.5	16.1	16.3	1.2	18.6	18.6	0.4	19.4	19.3	0.8
Rb	4.71	4.74	0.7	3.51	3.31	5.8	12.6	12.6	0.3	26.5	26.8	1.3
Sr	110	112	1.7	138	140	1.7	414	412	0.4	87.3	87.9	0.7
Y	22.2	22.3	0.0	15.2	15.4	1.5	21.4	21.3	0.5	26.8	26.8	0.3
Zr	59.1	59.2	0.2	39.6	39.6	0.0	163	164	0.9	65.0	65.4	0.5
Nb	3.47	3.46	0.2	2.22	2.28	2.7	42.5	42.6	0.3	2.53	2.54	0.5
Cs	0.328	0.326	0.4	0.185	0.186	0.4	0.646	0.646	0.0	2.43	2.44	0.5
Ba	17.0	17.0	0.3	36.4	36.7	1.0	175	173	1.0	16.8	16.7	0.6
La	2.99	3.00	0.5	2.61	2.62	0.4	28.5	28.4	0.2	2.29	2.27	1.1
Ce	8.21	8.20	0.1	6.96	7.01	0.6	59.4	59.0	0.7	6.94	6.86	1.2
Pr	1.34	1.34	0.4	1.11	1.12	0.9	7.06	7.02	0.5	1.18	1.16	1.6
Nd	7.26	7.21	0.7	5.85	5.92	1.1	27.7	27.3	1.5	6.78	6.67	1.6
Sm	2.55	2.56	0.7	1.97	2.00	1.6	5.53	5.45	1.5	2.67	2.69	0.9
Eu	0.99	0.99	0.2	0.779	0.791	1.6	1.75	1.74	0.5	1.07	1.08	0.9
Gd	3.30	3.32	0.6	2.50	2.55	1.7	5.08	5.05	0.5	3.78	3.78	0.2
Tb	0.610	0.611	0.1	0.446	0.454	1.9	0.792	0.780	1.5	0.720	0.723	0.4
Dy	4.08	4.05	0.7	2.88	2.93	1.8	4.43	4.39	0.9	5.00	4.96	0.8
Ho	0.870	0.862	1.0	0.601	0.618	2.8	0.847	0.839	1.0	1.08	1.07	0.6
Er	2.44	2.41	1.1	1.65	1.68	1.9	2.21	2.20	0.7	3.05	3.04	0.4
Tm	0.370	0.368	0.4	0.250	0.254	1.4	0.319	0.315	1.3	0.474	0.472	0.6
Yb	2.43	2.41	1.0	1.57	1.59	1.2	1.98	1.96	1.0	3.09	3.08	0.4
Lu	0.358	0.358	0.0	0.228	0.232	1.7	0.286	0.286	0.0	0.453	0.451	0.4
Hf	1.63	1.62	0.6	1.15	1.14	0.2	3.88	3.87	0.5	1.88	1.90	1.0
Ta	0.237	0.235	0.7	0.157	0.161	2.6	2.37	2.34	1.0	0.176	0.180	1.9
Pb	0.614	0.595	3.1	0.287	0.283	1.5	1.68	1.66	1.2	0.252	0.269	6.9
Th	0.264	0.262	0.8	0.220	0.236	6.9	2.70	2.68	0.9	0.218	0.220	0.6
U	0.119	0.120	0.8	0.103	0.102	1.6	0.657	0.652	0.8	0.223	0.227	1.6

Table B.5 Evaluation of instrument stability for ICP-MS based on multiple analyses of the same sample dissolution (Meas.1 - Meas.4).

Element (ppm)	M81-217-12 Meas.1	M81-217-12 Meas.2	M81-217-12 Meas.3	M81-217-12 Meas.4	Std. dev. ($\pm 1\sigma$ %)	M81-223-2 Meas.1	M81-223-2 Meas.2	M81-223-2 Meas.3	M81-223-2 Meas.4	Std. dev. ($\pm 1\sigma$ %)
Li	39.59	38.72	37.94	37.90	2.1	17.44	17.30	16.73	16.73	2.2
Sc	48.4	48.2	48.6	48.6	0.4	40.1	40.2	40.3	39.9	0.4
V	353	355	362	361	1.2	252	250	257	255	1.2
Cr	167	166	172	170	1.7	430	431	437	435	0.8
Co	48.2	48.5	48.8	48.9	0.6	36.4	36.7	36.6	36.5	0.4
Ni	83.1	83.4	84.2	84.5	0.8	132	132	133	132	0.4
Cu	152	151	153	153	0.5	150	151	151	150	0.2
Zn	97.4	97.1	97.7	97.6	0.3	63.1	63.2	63.6	63.1	0.4
Ga	16.5	16.4	16.7	16.5	0.7	16.5	16.5	16.6	16.4	0.6
Rb	4.20	4.19	4.32	4.39	2.3	4.07	4.08	4.29	4.51	5.0
Sr	240	241	246	246	1.4	141	143	146	145	1.5
Y	23.5	23.6	23.7	23.7	0.3	12.9	13.0	13.0	13.0	0.2
Zr	67.7	67.4	68.1	68.0	0.5	35.8	35.9	35.9	35.9	0.1
Nb	3.95	3.96	3.99	3.97	0.4	2.14	2.15	2.15	2.14	0.2
Cs	0.181	0.183	0.185	0.186	1.2	0.348	0.354	0.355	0.358	1.1
Ba	117	117	119	119	1.0	20	20	20	20	0.7
La	3.44	3.40	3.46	3.45	0.7	1.99	2.00	2.00	2.00	0.2
Ce	9.34	9.32	9.45	9.42	0.6	5.23	5.27	5.33	5.30	0.8
Pr	1.51	1.51	1.52	1.53	0.7	0.847	0.854	0.848	0.861	0.8
Nd	8.00	8.03	8.07	8.11	0.6	4.49	4.55	4.56	4.55	0.8
Sm	2.76	2.77	2.79	2.81	0.7	1.59	1.62	1.61	1.62	0.8
Eu	1.02	1.01	1.02	1.02	0.5	0.668	0.672	0.666	0.670	0.4
Gd	3.63	3.62	3.66	3.64	0.4	2.04	2.05	2.06	2.08	0.7
Tb	0.658	0.658	0.658	0.662	0.3	0.373	0.370	0.376	0.371	0.7
Dy	4.38	4.36	4.40	4.37	0.4	2.43	2.45	2.45	2.45	0.3
Ho	0.923	0.927	0.930	0.931	0.4	0.518	0.523	0.522	0.521	0.5
Er	2.58	2.58	2.60	2.61	0.5	1.45	1.45	1.45	1.47	0.7
Tm	0.393	0.399	0.402	0.398	1.0	0.226	0.226	0.227	0.225	0.4
Yb	2.59	2.57	2.61	2.61	0.7	1.45	1.47	1.45	1.44	0.9
Lu	0.381	0.380	0.383	0.385	0.5	0.218	0.220	0.219	0.218	0.4
Hf	1.89	1.88	1.89	1.89	0.3	1.05	1.06	1.06	1.06	0.4
Ta	0.262	0.262	0.264	0.266	0.6	0.150	0.150	0.151	0.152	0.5
Pb	0.238	0.237	0.240	0.238	0.6	0.214	0.216	0.218	0.214	0.8
Th	0.299	0.305	0.304	0.305	0.9	0.173	0.172	0.171	0.171	0.7
U	0.262	0.261	0.263	0.259	0.7	0.181	0.180	0.183	0.178	1.3

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