543 : 552.321.3/.323.5

Evaluation of Rb, Sr, K and Na Contents of the GSJ JG-1 Granodiorite and JB-1 Basalt

Atsushi ANDO* Hajime KURASAWA* and Shigeru UCHIUMI*

Abstract

Analytical results received by October 1974 for Rb, Sr, K and Na of the GSJ JG-1 granodiorite and JB-1 basalt are tabulated. Grand averages and precisions are provided. Results have been plotted in the form of histograms in which analytical methods are shown. Recommended values for these elements are given by the evaluation of all statistical results.

1. Introduction

Two geochemical rock samples JG–1 granodiorite and JB–1 basalt have been issued from the Geological Survey of Japan for the determination of major, minor, isotopic compositions and geological ages (ANDO, 1967; KURASAWA, 1968).

Data on a limited number of elements, namely Rb, Sr and isotopic ratios $^{87}Sr/^{86}Sr$ (KURASAWA, 1969), and comprehensive compilation of data for these rocks have previously been reported (ANDO et al., 1971). Best values for GSJ reference rocks have also been proposed (FLANAGAN, 1973). Recently a second comprehensive compilation of data for these rocks has been reported for major analysis, 53 minor elements, strontium isotopic ratios $^{87}Sr/^{86}Sr$ and geological ages (ANDO et al., 1974).

This is a statistical evaluation of the results namely for Rb, Sr, K and Na received by October 1974 for the GSJ reference rock samples JG–1 and JB–1. Recommended values for these elements are given.

2. Note on JG–1 and JB–1

JG–1 (Porphyritic biotite granodiorite) was collected from Sori, about 100 km north of Tokyo, Gumma Prefecture, Japan. The Sori granodiorite is exposed as a small mass of 6×12 km intruding into Paleozoic formation. The geological sheet map of "Ashio", scale 1 : 50,000 and its explanatory text has been published for this area (KAWADA and OZAWA, 1955). The age of 86 m.y. (SHIBATA and MILLER, 1963) and 87 m.y. (KAWANO and UEDA, 1966) were given for the Sori granodiorite body, and 85 m.y. for this JG–1 sample (SHIBATA, 1968), by K–Ar method.

JB–1 (Titanaugite-olivine basalt) was collected from Myokanji-Toge, about 7 km NNW of Sasebo City, Nagasaki Prefecture, Kyushu, Japan. A detailed geological and petrological study for this basalt has already been reported (KURASAWA, 1967). The basalt is exposed as a lava flow which constitutes and upper member of Kita-matsuura plateau basalt which is within the Japan Sea alkali rock province. The geological sheet map of "Nagasaki", scale 1 : 200,000 (IMAI et al., 1965) an "Northern Sasebo District", scale 1 : 25,000 (FURUKAWA, 1970) have

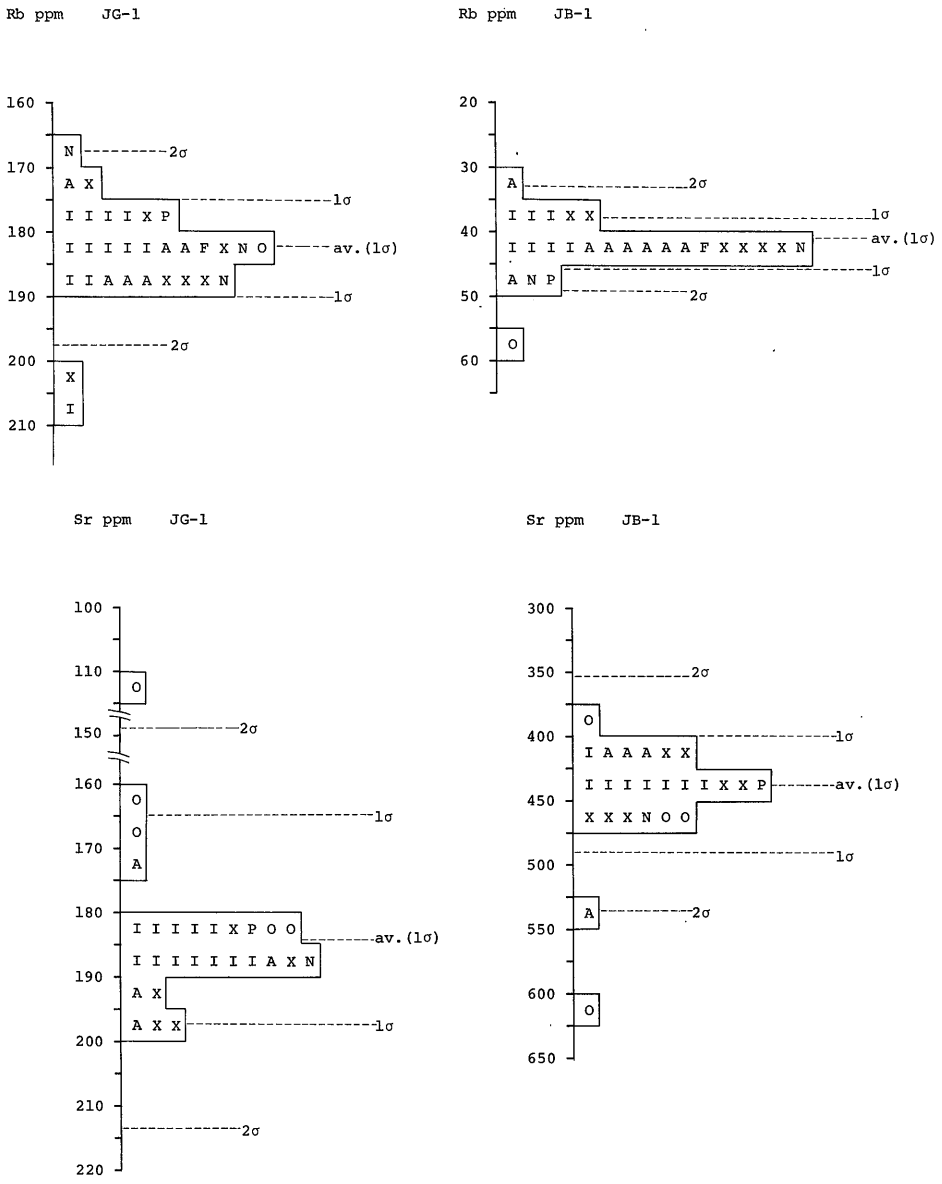
* Geochemistry and Technical Service Department

been published. An age of 8 m.y. was given by the K–Ar method for the corresponding member of the lava (Ozima et al., 1968).

3. Statistical evaluation of the results

All analytical results received by October 1974 are tabulated, and precision data are provided (Table 1, 2, 3, 4). Results have been plotted in the form of histograms in which analytical methods are shown (Fig. 1). Averages obtained by different analytical methods for these elements are given in Table 5.

Good agreements were obtained between average values of Rb for isotope dilution mass



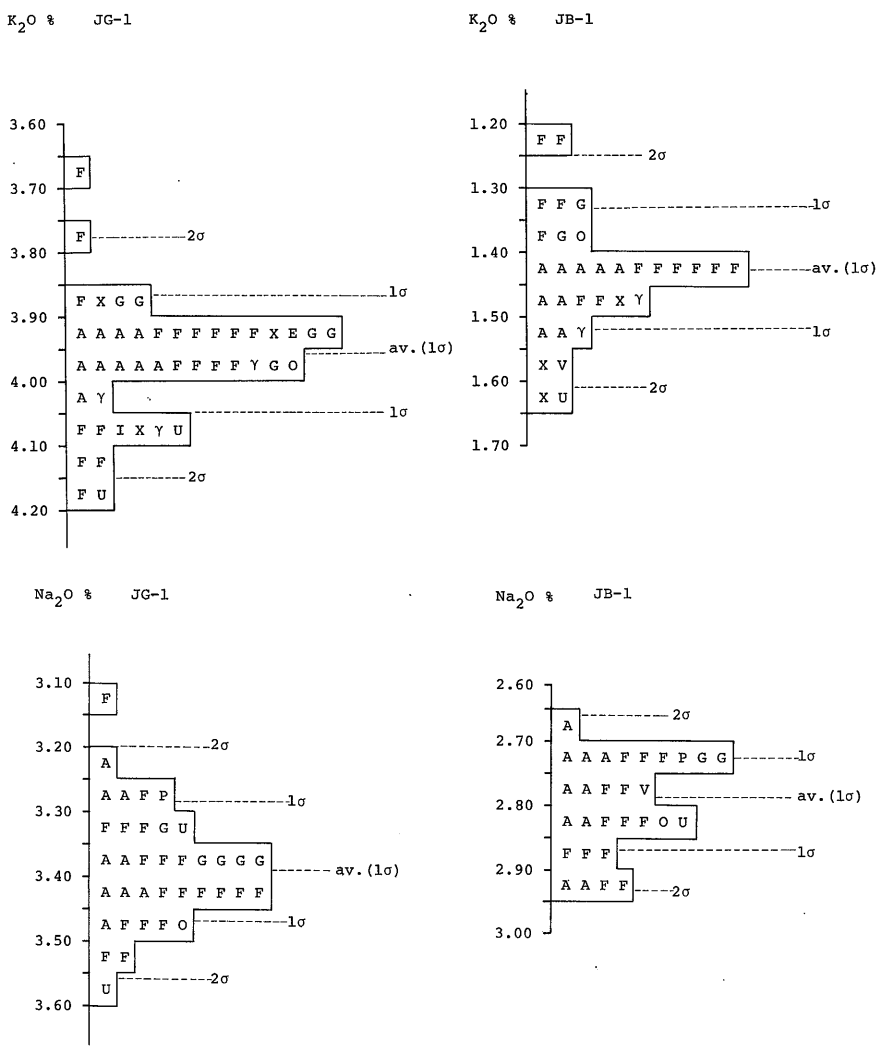


Fig. 1 Histograms

Abbreviations for Fig. 1 – Analytical methods –

A: AA (Atomic absorption spectrometry)
E: EPMA (Electron-probe micro-analyser)
F: Fl. Phot. (Flame photometry)
G: Grav. (Gravimetry)
I: ID (Isotope dilution mass spectrometry)
N: NAA (Neutron activation analysis)
O: OS (Optical emission spectrometry)
P: PAA (Photon activation analysis)
X: XRF (X-ray fluorescence spectrometry)
V: Vol. (Volmetric)
γ: γ-cntg. (γ-ray counting)
U: Unreported

spectrometry, atomic absorption spectrometry, flame photometry, and average (1σ) for all analytical results. For Sr a fairly good agreement was obtained between average values for isotope dilution mass spectrometry, neutron activation analysis, atomic absorption spectrometry and X-ray fluorescence spectrometry, and very good agreement was obtained between an average value for isotope dilution mass spectrometry and an average (1σ) for all analytical results. High precision results were obtained for Rb and Sr by isotope dilution mass spectro-

Table 1 Analytical results for rubidium for GSJ JG-1 and JB-1 (ppm).

JG-1	JB-1	Method	Reference
183	42.4	ID	HAYASE (1968)
180 (3)	40	ID	TAKEUCHI and SHIMA (1968)
207 (2)	44.9 (2)	ID	TANIGUCHI and OKADA (1968)
181 (4)	40.7 (3)	ID	TAMURA (1968)
188.2	43.4	ID	UEDA, N. (1968)
184.8 (2)	—	ID	YAMAGUCHI (1968)
181.8 (3)	—	ID	SATO, s. et al. (1969)
178 (3)	39.4 (3)	ID	SHIBATA et al. (1970)
179.5	—	ID	ISHIZAKA (1971)
179	38.9	ID	SHIBATA and ADACHI (1972)
—	39	ID	FUJIMAKI (1974)
178.9	—	ID	MAHON (1974)
178.9	—	ID	SHIRAHASE (1974)
168	41 (2)	NAA	TAKEUCHI and SHIMA (1968)
187 (2)	—	NAA	TOMURA et al. (1968)
183	<45[1)]	NAA	RANDLE (1974)
175.5 (2)	46 (2)	PAA	SATO, N. et al. (1974)
187	34	AA	PRICE (1969)
187 (4)	41 (3)	AA	UEDA, Y. et al. (1969)
—	42	AA	WEIGAND (1970)
181	48	AA	GOVINDARAJU et al. (1971)
—	40(11)	AA	STEELE (1971)
188	44	AA	RUBEŠKA (1972)
171	44	AA	OAKLEY (1973)
182 (3)	40 (3)	AA	TERASHIMA (1973)
184 (3)	41 (3)	Fl. Phot.	TERASHIMA (1973)
185	—	XRF	HATTORI and SHIBATA (1967)
202	39	XRF	HATTORI and SHIBATA (1969)
185	41	XRF	KURASAWA (1970)
179	41.5	XRF	BEASLEY (1972)
174	40	XRF	RUBEŠKA (1972)
181	38	XRF	MURAD (1973)
187	41	XRF	GAGNON (1974)
180 (3)	55 (3)	OS (DR)	THOMPSON (1972)
31	27	.....	n
182.8	41.7	.....	av.
7.5	3.9	.....	σ
4.1	9.3	.....	CV %
181.3	41.2	.....	av. (2σ)
182.5	41.0	.....	av. (1σ)

1) The value is not included in the statistical calculation.

metry (Table 6).

For K a good agreement were obtained between average values for flame photometry, atomic absorption spectrometry, chemical method, X-ray fluorescence spectrometry, γ-ray counting, isotope dilution mass spectrometry and an average (1σ) for all analytical results. For Na good agreement were obtained between average values for flame photometry, atomic absorp-

Table 2 Analytical results for strontium for GSJ JG-1 and JB-1 (ppm).

JG-1	JB-1	Method	Reference
182	447	ID	TAKEUCHI and SHIMA (1968)
182 (4)	425 (4)	ID	TAMURA (1968)
180.5 (2)	424 (2)	ID	TANIGUCHI and OKADA (1968)
185.1 (3)	445.1 (2)	ID	UEDA, N. (1968)
188.1 (3)	—	ID	YAMAGUCHI (1968)
184.9 (3)	—	ID	SATO, S. et al. (1969)
186 (2)	448	ID	SHIBATA et al. (1970)
186.8	—	ID	ISHIZAKA (1971)
181	—	ID	NAGASAWA (1971)
187.5	448	ID	SHIBATA and ADACHI (1972)
—	442	ID	FUJIMAKI (1974)
185.8	—	ID	MAHON (1974)
185.1	445	ID	SHIRAHASE (1974)
187 (2)	466	NAA	TAKEUCHI and SHIMA (1968)
182.5	447.5	PAA	SATO, N. et al. (1974)
170	547	AA	PRICE (1969)
191	424	AA	TERASHIMA (1971)
185	400	AA	RUBEŠKA (1972)
195	413	AA	OAKLEY (1973)
194	417	XRF	HATTORI and SHIBATA (1969)
—	450	XRF	WEIGAND (1970)
—	435	XRF	STEELE (1971)
185	450	XRF	BEASLEY (1972)
180	410	XRF	RUBEŠKA (1972)
199	450	XRF	MURAD (1973)
199	428	XRF	GAGNON (1974)
160	—	OS	CHAMP (1968)
165 (3)	390 (3)	OS (DR)	THOMPSON (1972)
110	455	OS	BRENNER (1973)
180	450	OS	CHAMP and BENDER (1973)
182	618	OS	GAGNON (1974)
28	25	.....	n
181.4	447.0	.....	av.
16.4	46.0	.....	σ
9.0	10.3	.....	CV %
184.1	435.2	.....	av. (2σ)
184.6	439.0	.....	av. (1σ)

Table 3 Analytical results for sodium and potassium for GSJ JG-1 (%).

Na_2O	K_2O	Method	Reference
3.31	4.09	Fl. Phot.	Res. Lab. Asahi Glass Co. Ltd. (1967)
3.45	4.17	Fl. Phot.	Mitaka Lab. Nittetsu Mining Co. Ltd. (1967)
3.14	3.92	Fl. Phot.	Cent. Res. Lab. Onoda Cement Co. Ltd. (1967)
3.44	4.10	Fl. Phot.	Haramura (1968)
3.38	4.05	Fl. Phot.	Nihon Cement Res. Lab. (1968)
—	4.11	Fl. Phot.	Zashu (1968)
3.38	4.05	Fl. Phot.	Aoki (1969)
3.44	3.96	Fl. Phot.	Onuki (1969)
3.42	3.94	Fl. Phot.	Aoki and Onuki (1969)
3.32	3.88	Fl. Phot.	Abe (1970)
3.42	3.99	Fl. Phot.	Ishibashi (1970)
3.48	3.76	Fl. Phot.	Murakami (1970)
3.52	3.67	Fl. Phot.	Nakao (1970)
3.46	3.99	Fl. Phot.	Oba (1970)
3.26	3.94	Fl. Phot.	Sugisaki and Tanaka (1971)
3.36	3.96	Fl. Phot.	Beasley (1972)
3.35	3.93	Fl. Phot.	Shirahata (1972)
3.33	3.93	Fl. Phot.	Maruyama and Suda (1974)
3.23	3.96	AA	Bouvier (1968)
3.43	3.94	AA	Kato (1969)
3.43	3.90	AA	Kato (1969)
—	3.91	AA	Kurasawa (1970)
—	3.96	AA	Shibata (1970)
3.36	3.92	AA	Terashima (1970)
3.43	3.97	AA	Tiba (1970)
3.28	—	AA	Weigand (1970)
3.27	—	AA	Steele (1971)
3.40	3.98	AA	Randall (1972)
3.48	4.00	AA	Gagnon (1974)
—	3.95	AA	Shibata and Uchiumi (1974)
3.39	3.94	Chem. (Grav.)	Munson (1967)
3.33	3.96	Chem. (Grav.)	Hikichi (1968)
3.39	3.86	Chem. (Grav.)	Maeda (1970)
3.35	3.88	Chem. (Grav.)	Ohmori (1970)
3.37	3.91	Chem. (Grav.)	Ohta (1972)
—	3.90	XRF	Sullivan (1970)
—	4.05	XRF	Murad (1971)
—	3.86	XRF	Steele (1971)
3.54	3.92	EPMA	Mori (1972)
3.45	3.95	OS (DR)	Govindaraju (1968)
—	3.95	γ-cntg.	Kanaya (1970)
—	4.03	γ-cntg.	Kanaya (1971)
—	4.05	γ-cntg.	Adams (1972)
—	4.05	ID	Ishizaka (1971)
3.25	—	PAA	Sato, N. et al. (1974)
3.59	4.17	Unreported	Vernet (1968)
3.34	4.06	Unreported	Friese (1972)
36	44	.....	n
3.38	3.96	.....	av.
0.091	0.094	.....	σ
2.69	2.36	.....	CV %
3.38	3.96	.....	av. (2σ)
3.39	3.96	.....	av. (1σ)

Table 4 Analytical results for sodium and potassium for GSJ JB-1 (%).

Na_2O	K_2O	Method	Reference
—	1.45	Fl. Phot.	Zashu (1968)
2.75	1.41	Fl. Phot.	Aoki (1969)
2.74	1.39	Fl. Phot.	Aoki and Onuki (1969)
2.74	1.41	Fl. Phot.	Onuki (1969)
2.91	1.46	Fl. Phot.	Abe (1970)
2.83	1.41	Fl. Phot.	Ishibashi (1970)
2.87	1.23	Fl. Phot.	Nakao (1970)
2.81	1.34	Fl. Phot.	Oba (1970)
2.93	1.20	Fl. Phot.	Uchida (1970)
2.85	1.31	Fl. Phot.	Sugisaki and Tanaka (1971)
2.84	1.40	Fl. Phot.	Beasley (1972)
2.77	1.40	Fl. Phot.	Shirahata (1972)
2.85	1.41	Fl. Phot.	Maruyama and Suda (1974)
2.74	1.44	AA	Kato (1969)
2.72	1.43	AA	Kato (1969)
2.68	1.47	AA	Bouvier (1970)
2.90	1.40	AA	Grushman (1970)
—	1.40	AA	Kurasawa (1970)
2.75	—	AA	Sullivan (1970)
2.73	1.40	AA	Terashima (1970)
2.79	1.46	AA	Tiba (1970)
2.83	—	AA	Weigand (1970)
2.72	—	AA	Steele (1971)
2.81	1.50	AA	Randall (1972)
2.90	1.50	AA	Gagnon (1974)
2.79	1.57	Chem. (Vol.)[1]	Takamura (1969)
2.71	1.34	Chem. (Grav.)	Ohmori (1970)
2.72	1.37	Chem. (Grav.)	Ohta (1972)
—	1.55	XRF	Sullivan (1970)
—	1.60	XRF	Weigand (1970)
—	1.49	XRF	Murad (1971)
2.83	1.38	OS (DR)	Govindaraju (1969)
—	1.49	γ-cntg.	Kanaya (1971)
—	1.51	γ-cntg.	Adams (1972)
2.73	—	PAA	Sato, N. et al. (1974)
2.82	1.62	Unreported	Vernet (1969)
29	32	.....	n
2.80	1.43	.....	av.
0.069	0.092	.....	σ
2.45	6.42	.....	CV %
2.80	1.44	.....	av. (2σ)
2.79	1.42	.....	av. (1σ)

1) After separation with Amberlite column, titrated with silver nitrate solution.

tion spectrometry, chemical method and an average (1σ) for all analytical results (Table 5).

Recommended values for these elements are given by the evaluation of all statistical results including hisograms (Table 7). Comments are given for the selection of the statistical results in Table 7. Recommended values indicate the average K/Rb and Rb/Sr ratios for these rock samples (Table 7).

Table 5 Averages by different analytical methods.

Component	Method	JG-1		JB-1	
		n	Average	n	Average
Rb ppm	ID	12	183.3	8	41.1
	NAA (PAA)	4	178.4	2	43.5
	AA	6	182.7	8	41.6
	Fl. Phot.	1	184	1	41
	XRF	7	184.7	6	40.1
	OS (DR)	1	180	1	55
	All methods	31	182.8	27	41.7
			182.5(1σ)		41.0(1σ)
Sr ppm	ID	12	184.6	8	440.5
	NAA (PAA)	2	184.8	2	446.8
	AA	4	185.3	4	446.0
	XRF	5	191.4	7	434.3
	OS	5	159.4	4	478.3
	All methods	28	181.4	25	447.0
			184.6(1σ)		439.0(1σ)
K_2O %	Fl. Phot.	18	3.97	13	1.37
	AA	10	3.95	9	1.44
	Chem.	5	3.91	3	1.43
	XRF	3	3.94	3	1.55
	EPMA	1	3.92	—	—
	OS (DR)	1	3.95	1	1.38
	γ-cntg.	3	4.01	2	1.50
	ID	1	4.05	—	—
	Others	2	4.12	1	1.62
	All methods	44	3.96	32	1.43
			3.96(1σ)		1.42(1σ)
Na_2O %	Fl. Phot.	17	3.38	12	2.82
	AA	9	3.37	11	2.78
	Chem.	5	3.37	3	2.74
	EPMA	1	3.54	—	—
	OS (DR)	1	3.45	1	2.83
	PAA	1	3.25	1	2.73
	Others	2	3.47	1	2.82
	All methods	36	3.38	29	2.80
			3.39(1σ)		2.79(1σ)

Table 6 Averages and precisions for Rb and Sr contents by isotope dilution mass spectrometry.

Component	Rocks	n	Average	σ	CV %
Rb ppm	JG-1	12	183.3	8.0	4.4
		11	181.2(1σ)	3.1	1.7
	JB-1	8	41.1	2.2	5.4
		6	40.1(1σ)		
Sr ppm	JG-1	12	184.6	2.6	1.4
		8	184.7(1σ)		
	JB-1	8	440.5	10.1	2.3
		6	445.9(1σ)		

Table 7 Recommended values.

Component	JG-1	JB-1	Note
Rb ppm	183	41	av. (ID): 183.3 and av. (1σ): 182.5 are taken for JG-1; av. (ID): 41.1 and av. (1σ): 41.0 are taken for JB-1.
Sr ppm	185	440	av. (ID): 184.6 and av. (1σ): 184.6 are taken for JG-1; av. (ID): 440.5 and av. (1σ): 439.0 are taken for JB-1.
K_2O %	3.96	1.42	av. (1σ) is taken.
Na_2O %	3.39	2.79	av. (1σ) is taken.
K/Rb	180	288	
Rb/Sr	0.9892	0.0932	

Abbreviations for the tables

AA:	Atomic absorption spectrometry
av.:	Average value (arithmetic mean)
av. (1σ):	Consensus average value (arithmetic mean of the values within $\pm 1\sigma$)
av. (2σ):	Consensus average value (arithmetic mean of the values within $\pm 2\sigma$)
Chem.:	Chemical method
CV %:	Coefficient of variation %
EPMA:	Electron-probe micro-analyser
Fl. Phot.:	Flame photometry
Grav.:	Gravimetry
ID:	Isotope dilution mass spectrometry
(n):	Number of determinations
NAA:	Neutron activation analysis
OS:	Optical emission spectrometry
OS (DR):	Direct reading optical emission spectrometry
PAA:	Photon activation analysis
XRF:	X-ray fluorescence spectrometry
Vol.:	Volmetry
γ-cntg.:	γ-ray counting
σ:	Standard deviation

4. Conclusions and recommendations

Although a good precision is shown by the results obtained for Rb, Sr, K and Na of the GSJ JG–1 and JB–1, further analysis is needed to conclude the more valid standard values, because the results for these elements by different analytical methods are still insufficient for a statistical evaluation.

We are indebted to all analysts who contributed data for these samples.

Any geochemists, geologists or analytical chemists interested in participating in our program are invited to write to Liaison Officer of Standard Samples, Geochemical Research Section, Geological Survey of Japan, 135 Hisamoto, Takatsu-ku, Kawasaki 213, Japan.

Acknowledgments

We thank Drs Ken SHIBATA and Naoki ISSHIKI for their kind advice and for reading the manuscript.

References

ABE, T. (1970) Private communication, Geological Survey of Japan, Sendai, Japan.

————J. A. S. (1972) Private communication, Rice University, Houston, Texas, U.S.A.

ANDO, A. (1967) A new silicate rock standard, JG–1 issued from the Geological Survey of Japan. *Geochem. J.*, vol. 1, p. 155.

ANDO, A., KURASAWA, H., OHMORI, T. and TAKEDA, E. (1971) 1971 compilation of data on rock standards JG–1 and JB–1 issued from the Geological Survey of Japan. *Geochem. J.*, vol. 5, p. 151–164.

————, ————, ———— and ———— (1974) 1974 compilation of data on the GSJ geochemical reference samples JG–1 granodiorite and JB–1 basalt. *Geochem. J.*, vol. 8, p. 175–192.

AOKI, K. (1969) See UEDA, Y. et al. (1969).

————. and ONUKI, H. (1969) See UEDA, Y. et al. (1969).

BEASLEY, P. H. (1972) Private communication, Department of Geophysics and Geochemistry, The Australian National University, Canberra, Australia.

BOUVIER, J. L. (1968, 1970) Private communications, Geological Survey of Canada, Otawa, Canada.

BRENNER, I. B. (1973) Private communication, Geological Survey of Israel, Jerusalem, Israel.

CENTRAL RESEARCH LABORATORY, ONODA CEMENT Co. Ltd. (1967) Private communication, Tokyo, Japan.

CHAMP, W. H. (1968) Private communication, Geological Survey of Canada, Ottawa, Canada.

CHAMP, W. H. and BENDER, G. P. (1973) Private communication, Geological Survey of Canada, Ottawa, Canada.

FLANAGAN, F. J. (1973) 1972 values for international geochemical reference samples. *Geochim. Cosmochim. Acta*, vol. 37, p. 1189–1200.

Friese, D. C. G. (1972) Quoted in Schmidt, K. (1972).

Fujimaki, H. (1974) Private communication, Geological Institute, University of Tokyo, Tokyo, Japan.

Furukawa, T. (1970) *Geological map of northern Sasebo district, scale 1: 25,000*, Geol. Surv. Japan.

Gagnon, J. (1974) Private communication, Service Analyse et Contrôle, Complexe Scientifique, Ste-Foy, Qué. Canada.

Govindaraju, K. (1968, 1969) Private communications, C.R.P.G., University of Nancy, Nancy, France.

———————— Mevelle, G. and Chouard, C. (1971) Direct atomic absorption determination of rubidium on pulverized silicate rock samples. *Chem. Geol.*, vol. 8, p. 131–137.

Grushman, V. E. (1970) Private communication, Geological Survey of Canada, Ottawa, Canada.

Haramura, H. (1968) Private communication, Geological Institute, University of Tokyo, Tokyo, Japan.

Hattori, H. and Shibata, K. (1967) Private communication, Geological Survey of Japan, Kawasaki, Japan. .

———————— and ———————— (1969) Quantitative analysis of Rb and Sr in rocks by X-ray fluorescence spectrometry. *Bull. Geol. Surv. Japan*, vol. 20, p. 51–76 (in Japanese with English abstract).

Hayase, I. (1968) Private communication, Kyoto University, Kyoto, Japan.

Hikichi, Y. (1968) Private communication, Nagoya Institute of Technology, Nagoya, Japan.

Imai, I., Matsui, K., Mizuno, A. and Nagahama, H. (1965) *The geological sheet map "Nagasaki", scale 1: 200,000*, Geol. Surv. Japan.

Ishibashi, K. (1970) Private communication, Kyushu University, Fukuoka, Japan.

Ishizaka, K. (1971) A Rb–Sr isotopic study of the Ibaragi granitic complex, Osaka, Japan. *J. Geol. Soc. Japan*, vol. 77, p. 731–740.

Kanaya, H. (1970, 1971) Private communication, Geological Survey of Japan, Kawasaki, Japan.

Kato, Y. (1969) See Ueda, Y. et al. (1969).

Kawada, K. and Ozawa, A. (1955) *The geological sheet map "Ashio", scale 1: 50,000, and its explanatory text.* 57 p., Geol. Surv. Japan (in Japanese with English abstract 7 p.).

Kawano, Y. and Ueda, Y. (1966) K–Ar dating on the igneous rocks in Japan (IV)—Granitic rocks in northeastern Japan—. *J. Jap. Assoc. Min. Pet. Econ. Geol.*, vol. 56, p. 41–55 (in Japanese with English abstract).

Kurasawa, H. (1967) Petrology of the Kita-matsuura basalt in the northwest Kyushu, southwest Japan. *Rept. Geol. Surv. Japan*, no. 217, 108 p.

———————— (1968) A new silicate rock standard, JB–1 issued from the Geological Survey of Japan. *Geochem. J.*, vol. 2, p. 185.

———————— (1969) First compilation of analytical data and strontium isotopes on the

new geochemical standards, JB–1 and JG–1. *Mass Spectros.*, vol. 17, p. 649–652 (in Japanese with English abstract).

KURASAWA, H. (1970) Private communication, Geological Survey of Japan, Kawasaki, Japan.

MAEDA, K. (1970) Private communication, Geological Survey of Japan, Kawasaki, Japan.

MAHON, M. (1974) Private communication, Department of Geophysics and Geochemistry, The Australian National University, Canberra, Australia.

MARUYAMA, G. and SUDA, M. (1974) Private communication, Mitsubishi Mining Cement Research Laboratory, Yokose, Saitama, Japan.

MITAKA LABORATORY, NITTETSU MINING Co. Ltd., (1967) Private communication, Tokyo, Japan.

MORI, T. (1972) Private communication, Kanazawa University, Kanazawa, Japan.

MUNSON, E. L. (1967) Private communication, U.S. Geological Survey, Denver, Colorado, U.S.A.

MURAD, E. (1971) Private communication, Mineralogisch-Petrographisches Institut der Universität, Tübingen, Germany.

———— (1973) Determination of trace elements in unfused rock and mineral samples by X-ray fluorescence. *Anal. Chim. Acta*, vol. 67, p. 37–53.

MURAKAMI, M. (1970) Private communication, Faculty of Liberal Arts, Yamaguchi University, Yamaguchi, Japan.

NAGASAWA, H. (1971) Private communication, NASA, Goddard, Maryland, U.S.A.

NAKAO, K. (1970) Private communication, Tokyo Kyoiku University, Tokyo, Japan.

NIHON CEMENT RESEARCH LABORATORY (1968) Private communication, Tokyo, Japan.

OAKLEY, P. J. (1973) Quoted in RANDALL, B. A. O. (1973).

OBA, Y. (1970) Private communication, Hokkaido University, Sapporo, Japan.

OHMORI, T. (1970) Private communication, Geological Survey of Japan, Kawasaki, Japan.

OHTA, K. (1972) Private communication, Tokyo Coal and Mineral Laboratory, Tokyo, Japan.

ONUKI, H. (1969) See UEDA, Y. et al. (1969).

OZIMA, M., KANEOKA, I., KANO, M., KINOSHITA, K., OHNAKA, N., NAGATA, T. and KURASAWA, H. (1968) Paleomagnetism and K–Ar ages of successive lava flows (2)—Kita-matsuura basalt, Kyushu, Japan. *J. Geomag. Geoelect.*, vol. 20, p. 85–92.

PRICE, V. (1969) Private communication, Furman University, Greenville, South Carolina, U.S.A.

RANDALL, B. A. O. (1972, 1973) Private communication, The University of Newcastle upon Tyne, Newcastle, England.

RANDLE, K. (1974) Some trace element data and thir interpretation for several new reference samples obtained by neutron activation analysis. *Chem. Geol.*, vol. 13, p. 237–256.

RESEARCH LABORATORY, ASAHI GLASS Co. Ltd. (1967) Private communication, Yokohama,

Japan.

Rubeška, I. (1972) Private communication, Geological Survey of Czechoslovakia, Prague, Czechoslovakia.

Sato, N., Kato, T. and Suzuki, N. (1974) Multielement photon activation analysis of rock materials with 30 MeV bremsstrahlung. *Radichim. Acta,* vol. 19, p. 1–6.

Sato, S., Iizumi, S. and Kagami, H. (1969) Variance in measurement of Rb and Sr isotopic ratios of the sample, and its effect to the age determination (as to the standard sample JG–1). *Mass Spectros.*, vol. 17, p. 522–529.

Schmidt, K. (1972) Private communication, Zentrales geologisches Institut, Berlin, DDR.

Shibata, K. (1968) K–Ar age determination on granitic and metasomatic rocks in Japan. *Rept. Geol. Surv. Japan*, no. 227, 71 p.

———— (1970) Private communication, Geological Survey of Japan, Kawasaki, Japan.

———— and Adachi, M. (1972) Rb–Sr and K–Ar geochronology of metamorphic rocks in the Kamiaso conglomerate, Central Japan. *J. Geol. Soc. Japan*, vol. 78, p. 265–271.

———— and Miller, J. A. (1963) Potassium-argon age of the Sori granodiorite, Ashio mountain block. *Bull. Geol. Surv. Japan*, vol. 14, p. 102.

———— Nozawa, T. and Wanless, R. K. (1970) Rb–Sr geochronology of the Hida metamorphic belt, Japan. *Can. J. Earth Sci.*, vol. 7, p. 1383–1401.

———— and Uchiumi, S. (1974) Private communication, Geological Survey of Japan, Kawasaki, Japan.

Shirahase, T. (1974) Private communication, Geological Survey of Japan, Kawasaki, Japan.

Shirahata, H. (1972) Private communication, Muroran Institute of Technology, Muroran, Japan.

Steele, K. F. (1971) Private communication, University of Arkansas, Fayetteville, Arkansas, U.S.A.

Sugisaki, R. and Tanaka, T. (1971) Collective analysis of silicate · rocks in the mass and analysis of standard rocks. *J. Geol. Soc. Japan*, vol. 77, p. 453–463 (in Japanese with English abstract).

Sullivan, J. G. (1970) Private communication, University of North Carolina, Chapel Hill, North Carolina, U.S.A.

Takamura, H. (1969) Analytical data on the geochemical standard JB–1 basalt. *J. Jap. Assoc. Min. Pet. Econ. Geol.*, vol. 62, p. 219–221 (in Japanese with English abstract).

Takeuchi, S. and Shima, Masako (1968) Private communication, Institute for Solid State Physics, University of Tokyo, Tokyo, Japan.

Tamura, S. (1968) Private communication, Japan Atomic Energy Research Institute, Tokai, Ibaragi, Japan.

Taniguchi, S. and Okada, S. (1968) Private communication, Radiation Center of Osaka Pref., Sakai, Japan.

Terashima, S. (1970) Interferences and their suppression in atomic absorption analysis

of minor elements in silicates. *Japan Analyst* (*Bunseki Kagaku*),vol. 19, p. 1197–1203 (in Japanese with English abstract).

TERASHIMA, S. (1971) Atomic absorption analysis of minor elements in silicates. *Japan Analyst* (*Bunseki Kagaku*), vol. 20, p. 321–326 (in Japanese with English abstract).

———— (1973) Atomic absorption analysis of Be, V, Ba, and Rb in rocks and flame emission analysis of Rb. *Bull. Geol. Surv. Japan*, vol. 24, p. 469–485 (in Japanese with English abstract).

THOMPSON, G. (1972) Private communication, Woods Hole Oceanographic Institute, Woods Hole, Massachusetts, U.S.A.

TIBA, T. (1970) JB–1 and JG–1—Geological Survey of Japan silicate rock standards—. *J. Geol. Soc. Japan*, vol. 76, p. 441–447.

TOMURA, K., HIGUCHI, H., TAKAHASHI, H., ONUMA, N. and HAMAGUCHI, H. (1968) Simultaneous determination of rubidium and cesium in rock samples by neutron activation analysis with a lithium-drafted germanium detector after chemical separation. *Anal. Chim. Acta*, vol. 43, p. 523–526.

UCHIDA, T. (1970) Private communication, Tokyo Kyoiku University, Tokyo, Japan.

UEDA, N. (1968) Private communication, University of Tokyo, Tokyo, Japan.

UEDA, Y., AOKI, K., ONUKI, H. and KATO, Y. (1969) Analytical data on the geochemical standards JB–1 basalt and JG–1 granodiorite. *J. Jap. Assoc. Min. Pet. Econ. Geol.*, vol. 61, p. 35–39 (in Japanese with English abstract).

VERNET, M. (1968, 1969) Quoted in GOVINDARAJU (1968, 1969).

WEIGAND, P. W. (1970) Major and trace element geochemistry of the Mesozoic dolerite dikes from eastern North America. Ph. D. Thesis, University of North Carolina, Chapel Hill, North Carolina, U.S.A.

YAMAGUCHI, M. (1968) Private communication, Kyushu University, Fukuoka, Japan.

ZASHU, S. (1968) Private communication, University of Tokyo, Tokyo, Japan.

地質調査所発行の標準岩石試料 JG-1 花崗閃緑岩および JB-1 玄武岩中の Rb, Sr, K および Na 含有量の推定

安藤 厚・倉沢 一・内海 茂

地質調査所発行の国際的地球化学的標準試料 JG-1 花崗閃緑岩および JB-1 玄武岩の Rb, Sr, K および Na 含有量について，1974年10月までの報告値を集計し，平均値および精度に関する数値を例示した．さらに，分析方法を例示した分析値のヒストグラムを作成し，方法別の分析結果と分析精度の検討を行った．ヒストグラムを含む統計的諸結果を比較検討し，現時点における JG-1 および JB-1 の Rb, Sr, K および Na の標準含有量を推定した．

JG-1 Rb: 183 ppm; Sr: 185 ppm; K_2O: 3.96%; Na_2O: 3.39%

JB-1 Rb: 41 ppm; Sr: 440 ppm; K_2O: 1.42%; Na_2O: 2.79%