1974 compilation of data on the GSJ geochemical reference samples JG-1 granodiorite and JB-1 basalt

ATSUSHI ANDO, HAJIME KURASAWA, TEIKO OHMORI and
EIZO TAKEDA

Geological Survey of Japan, Kawasaki 213, Japan

(Received December 6, 1974)

Abstract—Analytical data received by October, 1974 for rock analyses, 53 minor elements and strontium isotopic ratios of the GSJ JG-1 granodiorite and JB-1 basalt are tabulated. Averages for both major and minor elements are given.

The Geological Survey of Japan has issued two geochemical reference rock samples GSJ JG-1 granodiorite and JB-1 basalt for the determination of major, minor, isotopic compositions and geological ages. Locations, geological notes and processing of the samples have been reported (ANDO, 1967; KURASAWA, 1968). Data of rock analyses, 47 minor elements, strontium isotopic ratios ($^{87}\text{Sr}/^{86}\text{Sr}$), oxygen isotopic compositions and geological ages (K-Ar) received for these rocks by August, 1971, have previously been compiled (ANDO *et al.*, 1971). Best values for the GSJ reference samples have also been proposed (FLANAGAN, 1973). This is a second compilation of data received by October, 1974 for the GSJ geochemical reference rock samples JG-1 and JB-1.

JG-1 (Porphyritic biotite granodiorite) was collected from Sori, about 100km north of Tokyo, Gunma Prefecture, Japan. The Sori-granodiorite is exposed as a small mass of 6×12 km intruding into Paleozoic formation. An age of 85m.y was given by K-Ar method for this sample (SHIBATA, 1968).

JB-1 (Titanaugite-olivine basalt) was collected from Myokanji-Toge, about 7km NNW of Sasebo City, Kyushu, Japan. The basalt is exposed as a lava flow which constitutes an upper member of Kita-matsuura plateau basalt which is within the Japan Sea alkali rock province (KURASAWA, 1968). An age of 8m.y was given by the K-Ar method for another sample of the lava (OZIMA *et al.*, 1968). The age for JB-1 itself, however, has not been measured.

Additional data (received between August, 1971 and October, 1974) are tabulated

Publication authorized by the Director, Geological Survey of Japan.

for rock analyses (Tables 1, 2, 3) along with grand averages and precisions for all data (received between June, 1967 and October, 1974) (Table 4). All reported values are presented for 53 minor elements (Table 5) and strontium isotopic ratios ($^{87}\text{Sr}/^{86}\text{Sr}$) (Table 6), since only a limited number of analytical results were reported in the previous compilation.

In the tables (av.): arithmetic mean and (avc.): arithmetic mean of the values within 2σ are presented, because the results for many minor constituents are 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 Dr. D. S. MCKAY of NASA Manned Spacecraft Center, Houston, Texas, for his kind advice and for reading the manuscript.

Abbreviations in the tables

AA: Atomic absorption spectrometry	Fl. Phot.: Flame photometry	OS: Optical emission spectrometry
(av.): Average value (arithmetic mean)	Fluo.: Fluorescence spectrophotometry	OS(DR): Direct reading emission spectrometry
(avc.): Consensus average value (arithmetic mean of the values within 2σ)	FT: Fission track method	PAA: Photon activation analysis
α or cntg.: α or γ -ray counting	Grav.: Gravimetry	Photom.: Absorption spectrophotometry
Chem.: Chemical method	ID.: Isotope dilution mass spectrometry	Pyrohyd.: Pyrohydrolysis
Chromatg.: Chromatography	Kinetic: Catalytic reaction kinetics	Rapid: Rapid method
Color.: Colorimetry	M: Mass spectrometry	Rn: Radon method
Comb.: Combustion method	(n): Number of determinations	XRF: X-ray fluorescence spectrometry
EPMA: Electron-probe micro-analyser	NAA: Neutron activation analysis	Vol.: Volumetry
		σ : Standard deviation

Table 1. *Rock analyses, JG-1 (%)*

	25	26	27	28	29	30	31	32
SiO ₂	71.78	72.19	72.43	72.33	71.5	72.40	72.70	72.20
TiO ₂	0.26	0.26	0.26	0.28	0.09	0.28	0.29	0.27
Al ₂ O ₃	14.10	14.21	14.07	14.23	14.6	14.49	14.08	14.30
Fe ₂ O ₃	0.31	0.40	0.49	0.39	0.60	—	—	0.50
FeO	1.63	1.62	1.50	1.60	1.42	—	—	1.67
MnO	0.07	0.06	0.06	0.06	0.07	0.05	0.06	0.05
MgO	0.79	0.76	0.79	0.78	0.71	0.95	0.74	0.80
CaO	2.16	2.20	2.10	2.25	2.18	2.26	2.46	2.16
Na ₂ O	3.36	3.37	3.34	3.35	3.40	3.54	3.33	3.48
K ₂ O	3.96	3.91	4.06	3.93	3.98	3.92	3.93	4.00
P ₂ O ₅	0.12	0.11	0.10	0.09	—	—	0.09	0.09
H ₂ O+	0.83	0.48	0.61	0.50	0.31	—	—	0.67
H ₂ O-		0.08	—	0.11	—	—	0.08	0.04
CO ₂		0.07	0.08	—	—	—	—	0.11
Cl	—	—	—	—	—	—	—	—
F	—	—	—	—	—	—	—	—
Less O=F+Cl	—	—	—	—	—	—	—	—
Sum	99.37	99.72	99.89	99.90	98.86	—	—	100.34
Total Fe as Fe ₂ O ₃	2.12	2.20	2.16	2.17	2.18	2.34	2.20	2.36

25. BEASLEY (1972) XRF plus FeO (Chem. Vol.) Na & K (Fl. Phot.); 26. OHTA (1972) conventional methods; 27. FRIESE (1972) ditto, 28. SHIRAHATA (1972) ditto; 29. RANDALL (1972) AA plus Ti & FeO (Chem. Photom.); 30. MORI (1972) EPMA; 31. MARUYAMA and SUDA (1974) SiO₂ (Grav. plus Color.) Al, Ca & Mg (EDTA Vol.) total Fe (Chem. Vol.) Mn (AA) Na & K (Fl. Phot.) P (Chem. Photom.); 32. GAGNON (1974) SiO₂ (Grav. plus AA) FeO (Chem. Vol.) total Fe, Na, K & Mn (AA) Ca & Mg (EDTA Vol.).

Table 2. *Rock analyses, JB-1 (%)*

	18	19	20	21	22	23	24	25
SiO ₂	51.64	52.17	52.35	51.9	52.48	52.65	52.20	52.19
TiO ₂	1.30	1.36	1.38	1.15	1.36	1.34	1.34	1.32
Al ₂ O ₃	14.38	14.54	14.44	14.7	14.34	14.57	14.50	14.54
Fe ₂ O ₃	2.24	2.21	2.40	3.06	—	—	2.42	2.47
FeO	5.98	6.00	5.91	5.42	—	—	6.00	5.98
MnO	0.16	0.16	0.15	0.16	—	0.15	0.12	0.16
MgO	7.72	7.69	7.64	7.82	7.79	7.99	7.87	7.64
CaO	9.24	9.35	9.31	9.97	9.27	9.33	9.34	9.17
Na ₂ O	2.84	2.72	2.77	2.81	—	2.85	2.90	—
K ₂ O	1.40	1.37	1.40	1.50	—	1.41	1.50	—
P ₂ O ₅	0.29	0.27	0.26	—	—	0.26	0.25	0.25

(Continued)

H ₂ O+	2.02	0.94	0.90	0.93	—	—	0.75	—
H ₂ O-		0.84	0.85	—	—	0.99	0.85	—
CO ₂	—	—	—	—	—	—	0.21	—
Cr ₂ O ₃	—	—	0.046	—	—	—	—	—
Cl	—	—	—	—	—	—	—	—
F	—	—	—	—	—	—	—	—
Sum	99.21	99.82	99.81	—	—	—	100.25	—
Total Fe as Fe ₂ O ₃	8.89	8.88	8.97	9.08	9.08	8.89	9.09	9.12

18. BEASLEY (1972) XRF plus FeO(Chem. Vol.) Na & K(Fl. Phot.); 19. OHTA (1972) conventional methods; 20. SHIRAHATA (1972) ditto; 21. RANDALL (1972) AA plus Ti & FeO(Chem. Photom.); 22. MORI (1972) EPMA; 23. MARUYAMA and SUDA (1974) SiO₂(Grav. plus Color.) Al, Ca & Mg(EDTA Vol.) total Fe(Chem. Vol.) Mn(AA) Na & K(Fl. Phot.) P(Chem. Photom.); 24. GAGNON (1974) SiO₂(Grav. plus AA) FeO(Chem. Vol.) total Fe, Na, K & Mn(AA) Ca & Mg(EDTA Vol.); 25. HAYATA (1974) SiO₂(Grav.) Al, Ca, Mg, total Fe(EDTA Vol.) FeO(Chem. Vol.) Mn(Color.) Ti & P(Chem. Photom.).

Table 3. Rock analyses, individual determinations (%)

	JG-1	JB-1	Method	References
SiO ₂	73.81	53.05	NAA	HUYSMANS (1974)
TiO ₂	0.27	1.29	XRF	MURAD (1971)
	0.23	1.27	OS	CHAMP and BENDER (1973)
	0.29	1.49	OS	BRENNER (1973)
	0.255 (2)	1.21 (2)	PAA	SATO <i>et al.</i> (1974)
Al ₂ O ₃	14.53	14.67	NAA	HUYSMANS (1974)
Total Fe as Fe ₂ O ₃	2.28	8.78	XRF	MURAD (1971)
	2.07 (2)	8.74 (2)	PAA	SATO <i>et al.</i> (1974)
MgO	0.75	—	OS	CHAMP and BENDER (1973)
	0.785 (2)	7.96 (2)	PAA	SATO <i>et al.</i> (1974)
MnO	0.059	0.16	OS	CHAMP and BENDER (1973)
	0.072	0.14	AA	UCHIDA (1973)
	0.065	0.16	OS	BRENNER (1973)
	0.064	0.15	AA	GAGNON (1974)
	0.056 (2)	0.135 (2)	PAA	SATO <i>et al.</i> (1974)
CaO	2.11	9.31	XRF	MURAD (1971)
	1.43	—	OS	CHAMP and BENDER (1973)
	2.32 (2)	9.35 (2)	PAA	SATO <i>et al.</i> (1974)
Na ₂ O	3.25 (2)	2.73 (2)	PAA	SATO <i>et al.</i> (1974)
K ₂ O	4.05	1.49	XRF	MURAD (1971)
	4.05	—	ID	ISHIZAKA (1971)
	4.03	1.45	γ cntg.	KANAYA (1971)
	4.05	1.51	γ cntg.	ADAMS (1972)
	3.95	—	AA	SHIBATA and UCHIUMI (1974)
P ₂ O ₅	0.085	0.25	Color.	OAKLEY (1973)
Total H ₂ O	0.63	1.95	Grav.	TOGASHI (1972)

Table 4. *Grand averages and precisions for JG-1 and JB-1 analyses*

	n	JG-1			n	JB-1		
		$\bar{X}$	σ	$\bar{X}_c$		$\bar{X}_c$	σ	$\bar{X}_c$
SiO ₂	35	72.28	0.46	72.28	27	52.23	0.44	52.18
TiO ₂	40	0.26	0.042	0.27	31	1.35	0.10	1.34
Al ₂ O ₃	35	14.23	0.21	14.23	27	14.51	0.20	14.53
Fe ₂ O ₃	27	0.38	0.13	0.38	20	2.35	0.22	2.31
FeO	27	1.63	0.13	1.64	20	5.99	0.18	6.02
MnO	40	0.062	0.0086	0.061	30	0.15	0.011	0.15
MgO	39	0.74	0.082	0.73	32	7.72	0.14	7.74
CaO	42	2.20	0.11	2.17	30	9.27	0.18	9.24
Na ₂ O	36	3.38	0.091	3.38	29	2.80	0.069	2.80
K ₂ O	44	3.96	0.094	3.96	32	1.43	0.092	1.44
P ₂ O ₅	31	0.10	0.022	0.098	23	0.26	0.017	0.26
H ₂ O ⁺	24	0.53	0.14	0.52	17	0.97	0.25	0.97
H ₂ O ⁻	25	0.10	0.075	0.084	18	0.97	0.14	0.97
CO ₂	8	0.089	0.044	0.074	6	0.19	0.048	0.19
Sum		99.94		99.88		100.19		100.14
Total Fe as Fe ₂ O ₃	38	2.19	0.15	2.17	30	8.97	0.20	8.96
Total H ₂ O	26	0.64	0.15	0.64	19	1.92	0.26	1.96

n : Number of determinations $\bar{X}$: Arithmetic mean (%) σ : Standard deviation

$\bar{X}_c$: Consensus mean (Arithmetic mean of the analytical values within 2σ) (%)

Table 5. *Minor constituents (ppm)*

	JG-1	JB-1	Method	References
Ag	0.073	—	OS	CHAMP (1968)
	<1	<1	OS(DR)	THOMPSON (1972)
	<0.05	<0.05	OS	CHAMP and BENDER (1973)
	<1	2	AA	OAKLEY (1973)
	—	0.4	AA	GAGNON (1974)
As	<300	<300	AA	OAKLEY (1973)
	0.31	2.33	AA	TERASHIMA (1974b)
	0.24 (4)	1.88 (4)	NAA	TERADA (1974)
B	5.1	—	OS	CHAMP (1968)
	7	10	OS	IKEDA, K. (1970)
	12	16	OS	SCHMIDT (1972)
	8 (3)	4 (3)	OS(DR)	THOMPSON (1972)
	8.7 (6)	—	Photom.	ISOZAKI <i>et al.</i> (1973)
	<10	<10	OS	CHAMP and BENDER (1973)
	8.2 (av.)	—	—	—
Ba	430	—	OS	CHAMP (1968)
	470	—	ID	NAGASAWA (1971)
	460	545	AA	TERASHIMA (1971b)
	460 (3)	455 (3)	OS(DR)	THOMPSON (1972)
	430	440	AA	RUBEŠKA (1973)
	430	460	OS	CHAMP and BENDER (1973)
	463 (3)	485 (3)	AA	TERASHIMA (1973b)
	525	595	XRF	MURAD (1973)
	500	390	OS	BRENDER (1973)
	—	—	—	—

(Continued)

	JG-1	JB-1	Method	References
Ba	445	501	XRF	GAGNON (1974)
	603	580	OS	GAGNON (1974)
	440	320	NAA	RANDLE (1974)
	495 (2)	515 (2)	AA	RUBESKA (1974)
	—	511	ID	TANAKA, TS. (1974)
	473 (av.)	476 (av.)		
	462 (avc.)	490 (avc.)		
Be	<3	—	OS	CHAMP (1968)
	—	1	OS	SCHMIDT (1972)
	2.4	—	OS	CHAMP and BENDER (1973)
	3.3 (5)	1.6 (5)	AA	TERASHIMA (1973a)
Bi	0.62	—	OS	CHAMP (1968)
	<2	<2	OS(DR)	THOMPSON (1972)
	<0.5	—	OS	CHAMP and BENDER (1973)
	2.0	2.0	AA	GAGNON (1974)
Br	0.068 (3)	0.60 (3)	NAA	AKAIWA <i>et al.</i> (1971)
Cd	0.06 (2)	—	AA	YAMADA <i>et al.</i> (1969)
	0.046	0.114	AA	YAMADA <i>et al.</i> (1970)
	<2	<2	OS	THOMPSON (1972)
	<0.2	<0.2	AA	GAGNON (1974)
Ce	42.4	66.4	ID	NAGASAWA (1971)
	42.85	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	67.9	ID	TANAKA, TS. and MASUDA, A. (1971)
	41.9 (3)	67.1	NAA	MASUDA, Y. and YAGI (1971)
	47	65	NAA	RANDLE (1974)
	44.5 (2)	70 (2)	PAA	SATO <i>et al.</i> (1974)
	—	67.1	ID	TANAKA, TS. (1974)
	43.2 (av.)	67.3 (av.)		
Cl	200	—	Photom.	SEN GUPTA (1968)
	57	190	NAA	AKAIWA <i>et al.</i> (1971)
	67 (5)	167 (5)	Photom.	TERASHIMA (1974a)
	54 (5)	169 (5)	Photom.	TERADA and HIRAKAWA (1974)
	59 (avc.)	175 (av.)		
Co	<20	—	OS	CHAMP (1968)
	4.2	—	AA	NAGURA and IIDA (1968)
	—	39 (7)	AA	WEIGAND (1970)
	8.8	49	AA	TERASHIMA (1971a)
	11 (4)	27 (4)	AA	STEELE (1971)
	4.04 (3)	37.8 (3)	NAA	MASUDA, Y. and YAGI (1971)
	5	44	XRF	BEASLEY (1972)
	6	38	OS	SCHMIDT (1972)
	<2	23 (3)	OS(DR)	THOMPSON (1972)
	16	46	AA	OAKLEY (1973)
	—	31	OS	CHAMP and BENDER (1973)
	4.3 (3)	37.5 (6)	AA	SCHAFER (1973)
	2	35	AA	UCHIDA (1973)
	28	55	AA	GAGNON (1974)
	9	40	XRF	GAGNON (1974)
	4.0 (6)	40 (10)	AA	KAWABE (1974)
	3.87	41.6	NAA	RANDLE (1974)
	4.85 (2)	42	PAA	SATO <i>et al.</i> (1974)

(Continued)

	JG-1	JB-1	Method	References
Co	7.9 (av.) 6.4 (avc.)	39.1 (av.) 39.1 (avc.)		
Cr	31 52 — 62 51 43.4 (3) 64 52 40 55 (3) 46 58 48 — 64 58 — 42 51 51 (9) 58 51.5 (av.) 52.7 (avc.)	— 344 430 433 463 (3) 329 (3) 360 362 480 615 (3) 315 340 520 398 (3) 466 437 490 265 370 400 (19) 500 416 (av.) 405 (avc.)	OS AA XRF AA XRF NAA AA XRF OS OS(DR) Color. AA OS AA AA XRF OS AA XRF Photom. NAA	CHAMP (1968) PRICE (1969) WEIGAND (1970) TERASHIMA (1971b) STEELE (1971) MASUDA, Y. and YAGI (1971) RUBEŠKA (1972) RUBEŠKA (1972) SCHMIDT (1972) THOMPSON (1972) SHIRAHATA (1972) OAKLEY (1973) CHAMP and BENDER (1973) SCHAFFER (1973) UCHIDA (1973) MURAD (1973) BRENNER (1973) GAGNON (1974) GAGNON (1974) KAWABE (1974) RANDLE (1974)
Cs	10.6 10.1 (3) 9.3 (5) 10.3 10.1 (av.)	— 1.0 (3) 1.1 (5) 1.3 1.1 (av.)	NAA NAA Fl. Phot. NAA	TOMURA, H., T., O. and H. (1968) MASUDA, Y. and YAGI (1971) RUBESKA (1971) RANDLE (1974)
Cu	3 <8 3.4 16 12 (3) 3.5 3 4.0 <10 <5 <2 5 <5 2.3 (5) — 4 1 1.8 (6) 4.9 (av.) 3.9 (avc.)	— — 40 51 (5) 58 (6) 57 61 52 47 57 65 (2) 54 57 52 (5) 53 55 61 55 (10) 54.7 (av.) 55.7 (avc.)	AA OS OS AA AA AA XRF AA XRF OS OS(DR) AA OS AA AA AA XRF AA	NAGURA and IIDA (1968) CHAMP (1968) IKEDA, K. (1970) WEIGAND (1970) STEELE (1971) TERASHIMA (1971a) BEASLEY (1972) RUBEŠKA (1972) RUBEŠKA (1972) SCHMIDT (1972) THOMPSON (1972) OAKLEY (1973) CHAMP and BENDER (1973) SCHAFFER (1973) UCHIDA (1973) GAGNON (1974) GAGNON (1974) KAWABE (1974)
Dy	4.66 (2)	—	NAA	TOMURA, H., O. and H. (1968)

(Continued)

	JG-1	JB-1	Method	References
Dy	3.07	4.06	ID	NAGASAWA (1971)
	3.41	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	4.25	ID	TANAKA, TS. and MASUDA, A. (1971)
	—	4.13	ID	TANAKA, TS. (1974)
Er	1.57	2.19	ID	NAGASAWA (1971)
	1.63	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	2.35	ID	TANAKA, TS. and MASUDA, A. (1971)
	—	2.31	ID	TANAKA, TS. (1974)
Eu	0.69	1.48	ID	NAGASAWA (1971)
	0.708	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	1.54	ID	TANAKA, TS. and MASUDA, A. (1971)
	0.62	1.54	ID	MASUDA, Y. and YAGI (1971)
	0.75	1.50	NAA	RENDLE (1974)
	—	1.55	ID	TANAKA, TS. (1974)
	0.69 (av.)	1.52 (av.)		
F	500	—	Photom.	MUNSON (1967)
	800	—	Photom.	SEN GUPTA (1968)
	482	372	Pyrohyd.- ALC Photom.	SAKURAMOTO (1972)
	521	433	Pyrohyd.- ion meter	TODA (1973)
	470	390	Pyrohyd.- ion meter	UCHIDA (1973)
	510	360	Photom.	AKAIWA and AIZAWA (1973)
	491 (5)	365 (5)	Photom.	TERASHIMA (1974a)
	513 (3)	419 (3)	Pyrohyd.- ion meter	RUBESKA (1974)
	498 (avc.)	390 (av.)		
Ga	28	—	OS	CHAMP (1968)
	16	17	OS	IKEDA, K. (1970)
	18	14	OS	SCHMIDT (1972)
	15 (3)	19 (3)	OS(DR)	THOMPSON (1972)
	9.1	11	OS	CHAMP and BENDER (1973)
	15	22	XRF	GAGNON (1974)
	15 (avc.)	17 (av.)		
Ge	1.2	—	OS	CHAMP (1968)
	<0.7	<0.7	OS	CHAMP and BENDER (1973)
Gd	3.86	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	4.80	ID	TANAKA, TS. and MASUDA, A. (1971)
	—	4.84	ID	TANAKA, TS. (1974)
Hg (ppb)	7 (15)	14 (11)	AA	ANDO (1971)
	15	30	AA	GAGNON (1974)
Hf	3.1 (3)	3.5 (3)	NAA	MASUDA, Y. and YAGI (1971)
	3.8	3.2	NAA	RANDLE (1974)
I (ppb)	15 (4)	29 (4)	Kinetic	FUKASAWA (1973)
La	21.48	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	37.3	ID	TANAKA, TS. and MASUDA, A. (1971)
	26.3 (3)	34.9	NAA	MASUDA, Y. and YAGI (1971)
	18	36	XRF	GAGNON (1974)
	22.5	35.9	NAA	RANDLE (1974)
	—	36.7	ID	TANAKA, TS. (1974)

(Continued)

	JG-1	JB-1	Method	References
La	22.1 (av.)	36.2 (av.)		
Li	99.3	7.67	AA	PRICE (1969)
	106	12	AA	WEIGAND (1970)
	96	11	AA	TERASHIMA (1971a)
	—	10 (5)	AA	STEELE (1971)
	84	11.7	AA	RUBESKA (1972)
	95 (3)	16 (3)	OS(DR)	THOMPSON (1972)
	83	12	AA	OAKLEY (1973)
	—	11 (6)	AA	SCHAFER (1973)
	94 (av.)	11.4 (av.)		
Lu	0.238	0.302	ID	NAGASAWA (1971)
	0.22	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	0.31	ID	TANAKA, TS. and MASUDA, A. (1971)
	0.52	0.29	NAA	MASUDA, Y. and YAGI (1971)
	0.45	0.33	NAA	RANDLE (1974)
	—	0.307	ID	TANAKA, TS. (1974)
		0.31 (av.)		
Mo	2.3	—	OS	CHAMP (1968)
	2.2	16	OS	IKEDA, K. (1970)
	—	30	OS	SCHMIDT (1972)
	2	22 (3)	OS(DR)	THOMPSON (1972)
	1.0	8	OS	CHAMP and BENDER (1973)
	2	48	AA	GAGNON (1974)
Nb	—	20	OS	SCHMIDT (1972)
	11.5 (2)	15 (2)	PAA	SATO <i>et al.</i> (1974)
	13	27	XRF	GAGNON (1974)
Nd	18.5	20.8	ID	NAGASAWA (1971)
	20.58	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	27.0	ID	TANAKA, TS. and MASUDA, A. (1971)
	<30	<30	NAA	RANDLE (1974)
	—	26.6	ID	TANAKA, TS. (1974)
Ni	<20	—	OS	CHAMP (1968)
	6.1	—	AA	NAGURA and IIDA (1968)
	—	137	XRF	WEIGAND (1970)
	7.0	148	AA	TERASHIMA (1971a)
	14 (2)	132 (4)	XRF	STEELE (1971)
	6	143	XRF	BEASLEY (1972)
	<30	145	AA	RUBESKA (1972)
	<10	120	XRF	RUBESKA (1972)
	8	120	OS	SCHMIDT (1972)
	6 (3)	110 (3)	OS(DR)	THOMPSON (1972)
	12	139	AA	OAKLEY (1973)
	—	130	OS	CHAMP and BENDER (1973)
	6 (4)	129 (5)	AA	SCHAFER (1973)
	6	122	AA	UCHIDA (1973)
	20	146	AA	GAGNON (1974)
	9	88	XRF	GAGNON (1974)
	11.5 (2)	166 (2)	PAA	KATO <i>et al.</i> (1974)
	6.3 (6)	140 (10)	AA	KAWABE (1974)
	9.1 (av.)	132 (av.)		
	8.2 (avc.)	135 (avc.)		
O (%)	49.40	45.66	NAA	HUYSMANS (1973)

(Continued)

	JG-1	JB-1	Method	References
Os	0.0027 (5)	0.0019 (5)	NAA	TERADA <i>et al.</i> (1972)
Pb	24	—	AA	NAGURA and IIDA (1968)
	23	—	OS	CHAMP (1968)
	24.9	—	AA	TANAKA, TA. and IIDA (1969)
	21	16	AA	PRICE (1969)
	28	14.5	OS	IKEDA, K. (1970)
	24	11	AA	TERASHIMA (1971a)
	26	7.6	XRF	BEASLEY (1972)
	27	9.3	AA	RUBEŠKA (1972)
	23	10	XRF	RUBEŠKA (1972)
	20	9	OS	SCHMIDT (1972)
	32 (3)	12 (3)	OS(DR)	THOMPSON (1972)
	28	23	AA	OAKLEY (1973)
	22	6.7	OS	CHAMP and BENDER (1973)
	32	15	AA	UCHIDA (1973)
	27	5	XRF	MURAD (1973)
	25	—	AA	GAGNON (1974)
	33	15	XRF	GAGNON (1974)
	26 (6)	7 (10)	AA	KAWABE (1974)
	25.9 (av.)	11.5 (avc.)		
	25.9 (avc.)	10.6 (avc.)		
Ra ($\mu\text{g/g}$)	1.24	0.72	Rn	NISHIMURA (1969)
Rb	185	—	XRF	HATTORI and SHIBATA (1967)
	187 (2)	—	NAA	TOMURA, H., T., O. and H. (1968)
	207 (2)	44.9 (2)	ID	TANIGUCHI and OKADA (1968)
	183	42.4	ID	HAYASE (1968)
	181 (4)	40.7 (3)	ID	TAMURA (1968)
	188.2	43.4	ID	UEDA, N. (1968)
	180 (3)	40	ID	TAKEUCHI and SHIMA, MAS. (1968)
	168	41 (2)	NAA	TAKEUCHI and SHIMA, MAS. (1968)
	184.8 (2)	—	ID	YAMAGUCHI (1968)
	187	34	AA	PRICE (1969)
	187 (4)	41 (3)	AA	UEDA, Y. <i>et al.</i> (1969)
	202	39	XRF	HATTORI and SHIBATA (1969)
	181.8 (3)	—	ID	SATO, S. <i>et al.</i> (1969)
	185	41	XRF	KURASAWA (1970)
	178 (3)	39.4 (3)	ID	SHIBATA <i>et al.</i> (1970)
	—	42	AA	WEIGAND (1970)
	—	40 (11)	AA	STEELE (1971)
	181	48	AA	GOVINDARAJU <i>et al.</i> (1971)
	179.5	—	ID	ISHIZAKA (1971)
	179	38.9	ID	SHIBATA and ADACHI (1972)
	179	41.5	XRF	BEASLEY (1972)
	188	44	AA	RUBEŠKA (1972)
	174	40	XRF	RUBEŠKA (1972)
	180 (3)	55 (3)	OS(DR)	THOMPSON (1972)
	171	44	AA	OAKLEY (1973)
	182 (3)	40 (3)	AA	TERASHIMA (1973b)
	184 (3)	41 (3)	Fl. Phot.	TERASHIMA (1973b)
	181	38	XRF	MURAD (1973)
	187	41	XRF	GAGNON (1974)

(Continued)

	JG-1	JB-1	Method	References
Rb	—	39	ID	FUJIMAKI (1974)
	178.9	—	ID	MAHON (1974)
	183	<45	NAA	RANDLE (1974)
	175.5 (2)	46 (2)	PAA	SATO <i>et al.</i> (1974)
	178.9	—	ID	SHIRAHASE (1974)
	182.8 (av.)	41.7 (av.)		
	181.3 (avc.)	41.2 (avc.)		
S	—	50 (3)	Comb. Vol.	BOUVIER (1970)
	23 (6)	40 (2)	Photom.	OZAWA <i>et al.</i> (1972)
Sb	<2.0	<2.0	AA	GAGNON (1974)
	0.10	0.24	AA	TERASHIMA (1974b)
	<0.6	0.22	NAA	RANDLE (1974)
Sc	<20	—	OS	CHAMP (1968)
	6.44	25.6	NAA	MASUDA, Y. and YAGI (1971)
	8.0	32	OS	CHAMP and BENDER (1973)
	6.54	27.5	NAA	RANDLE (1974)
Se	0.0027	0.026	NAA	TERADA <i>et al.</i> (1974)
Sm	4.15	4.93	ID	NAGASAWA (1971)
	4.48	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	5.1	ID	TANAKA, TS. and MASUDA, A. (1971)
	4.51 (3)	4.31 (3)	NAA	MASUDA, Y. and YAGI (1971)
	5.4	4.7	NAA	RANDLE (1974)
	—	5.16	ID	TANAKA, TS. (1974)
	4.6 (av.)	4.8 (av.)		
Sn	3	—	OS	CHAMP (1968)
	3	2.3	OS	IKEDA, K. (1970)
	—	4	OS	SCHMIDT (1972)
	3.1	1.4	OS	CHAMP and BENDER (1973)
	4.1 (3)	2.1 (3)	AA	TERASHIMA (1974c)
Sr	182 (4)	425 (4)	ID	TAMURA (1968)
	182.5	447	ID	TAKEUCHI and SHIMA, MAS. (1968)
	187 (2)	466	NAA	TAKEUCHI and SHIMA, MAS. (1968)
	185.1 (3)	455.1 (2)	ID	UEDA, N. (1968)
	180.5 (2)	424 (2)	ID	TANIGUCHI and OKADA (1968)
	188.1 (3)	—	ID	YAMAGUCHI (1968)
	160	—	OS	CHAMP (1968)
	184.9 (3)	—	ID	SATO, S. <i>et al.</i> (1969)
	170	547	AA	PRICE (1969)
	194	417	XRF	HATTORI and SHIBATA (1969)
	186 (2)	448	ID	SHIBATA <i>et al.</i> (1970)
	—	450	XRF	WEIGAND (1970)
	181	—	ID	NAGASAWA (1971)
	191	424	AA	TERASHIMA (1971a)
	—	435	XRF	STEELE (1971)
	186.8	—	ID	ISHIZAKA (1971)
	187.5	448	ID	SHIBATA and ADACHI (1972)
	185	450	XRF	BEASLEY (1972)
	185	400	AA	RUBEŠKA (1972)
	180	410	XRF	RUBEŠKA (1972)
	165 (3)	390 (3)	OS(DR)	THOMPSON (1972)
	195	413	AA	OAKLEY (1973)

(Continued)

	JG-1	JB-1	Method	References
Sr	180	450	OS	CHAMP and BENDER (1973)
	199	450	XRF	MURAD (1973)
	110	455	OS	BRENNER (1973)
	—	442	ID	FUJIMAKI (1974)
	185.1	445	ID	SHIRAHASE (1974)
	185.8	—	ID	MAHON (1974)
	199	428	XRF	GAGNON (1974)
	182	618	OS	GAGNON (1974)
	182.5	447.5	PAA	SATO <i>et al.</i> (1974)
	181.4 (av.)	447.0 (av.)		
Ta	184.1 (avc.)	435.2 (avc.)		
	2.9	4.4	NAA	RANDLE (1974)
Tb	0.43 (3)	0.47	NAA	MASUDA, Y. and YAGI (1971)
Th	13.4	—	Photom.	MIYAKE and SUGIYAMA (1967)
	14	—	Photom.	SEKINE and MOCHIZUKI (1968)
	14	—	γ cntg.	SHIMA, MAKOTO (1968)
	13.2	9.2	γ cntg.	KANAYA (1970)
	11.5	7.8	α cntg.	MIYAKE <i>et al.</i> (1970)
	13.7 (3)	11.8	NAA	MASUDA, Y. and YAGI (1971)
	13.4	8.95	γ cntg.	KANAYA (1971)
	13	9	XRF	BEASLEY (1972)
	15.6	9.8	γ cntg.	ADAMS (1972)
	13.1 (2)	9.04	Photom.	KIRIYAMA and KURODA (1974)
	13.8	8.9	NAA	RANDLE (1974)
Tl	13.5 (av.)	9.3 (av.)		
	13.5 (avc.)	9.0 (avc.)		
	2.3	—	OS	CHAMP (1968)
U	2.5	—	OS	IKEDA, K. (1970)
	1.0	—	OS	CHAMP and BENDER (1973)
	3.1	—	Photom.	MIYAKE and SUGIMURA (1967)
U	3.0	1.5	Fluo.	SEKINE and MOCHIZUKI (1968)
	3.1	—	γ cntg.	SHIMA, MAKOTO (1968)
	3.7	—	eq. U(Ra)	NISHIMURA (1969)
	3.5	2.0	FT	HASHIMOTO (1969)
	3.3	1.8	FT	NISHIMURA (1970)
	3.3	—	NAA	NISHIMURA (1970)
	3.2	1.7	α cntg.	MIYAKE <i>et al.</i> (1970)
	—	1.9	γ cntg.	KANAYA (1970)
	4.67	1.72	γ cntg.	KANAYA (1971)
	5.0	1.6	γ cntg.	ADAMS (1972)
	2	2	XRF	BEASLEY (1972)
	3.0	1.85	NAA	IKEDA, N. (1972)
	4.2	1.84	Photom.	KIRIYA and KURODA (1974)
	2.5	—	Chromatg.	GAGNON (1974)
	3.4 (av.)	1.8 (av.)		
	3.3 (avc.)	1.8 (avc.)		
V	25	—	OS	CHAMP (1968)
	21	390	OS	IKEDA (1970)
	25	200	Photom.	TERASHIMA (1970)
	<25	223	AA	RUBEŠKA (1972)
	—	205	OS	SCHMIDT (1972)

(Continued)

	JG-1	JB-1	Method	References
V	95 (3)	170 (3)	OS(DR)	THOMPSON (1972)
	28	240	OS	CHAMP and BENDER (1973)
	25 (5)	227 (6)	AA	SCHAFER (1973)
	21 (5)	215 (5)	AA	TERASHIMA (1973a)
	22	220	OS	BRENNER (1973)
	25	228	AA	GAGNON (1974)
	21	217	XRF	GAGNON (1974)
	23.3	178	Photom.	AKAIWA <i>et al.</i> (1974)
	30 (av.)	226 (avc.)		
W	24 (avc.)	211 (avc.)		
	—	14	XRF	GAGNON (1974)
Y	30	—	OS	CHAMP (1968)
	32	26	XRF	BEASLEY (1972)
	—	24 (3)	OS(DR)	THOMPSON (1972)
	<30	<30	OS	CHAMP and BENDER (1973)
	30.5 (2)	26.5 (2)	PAA	SATO <i>et al.</i> (1974)
	30.8 (av.)	25.5 (av.)		
Yb	<10	—	OS	CHAMP (1968)
	1.52	2.01	ID	NAGASAWA (1971)
	1.48	—	ID	NAKAMURA and MASUDA, A. (1971)
	—	2.15	ID	TANAKA, TS. and MASUDA, A. (1971)
	2.50	2.18	NAA	MASUDA, Y. and YAGI (1971)
	<4	<4	OS	CHAMP and BENDER (1973)
	2.5	1.2	NAA	RANDLE (1974)
	—	2.13	ID	TANAKA, TS. (1974)
Zn	35	—	OS	CHAMP (1968)
	30	71.5	AA	PRICE (1969)
	46	95	AA	KATO, Y. (1970)
	—	86	AA	WEIGAND (1970)
	35	83	AA	TERASHIMA (1971a)
	34	78	AA	STEELE (1971)
	41	91	XRF	BEASLEY (1972)
	49	90	AA	RUBEŠKA (1972)
	45	86	XRF	RUBEŠKA (1972)
	35 (3)	170 (3)	OS(DR)	THOMPSON (1972)
	39	82	AA	OAKLEY (1973)
	38	79	OS	CHAMP and BENDER (1973)
	40	84	AA	UCHIDA (1973)
	44	74	XRF	MURAD (1973)
	45	77	AA	GAGNON (1974)
	48	98	XRF	GAGNON (1974)
	40 (av.)	90 (av.)		
	40 (avc.)	84 (avc.)		
Zr	74	—	OS	CHAMP (1968)
	—	148	XRF	WEIGAND (1970)
	—	163	XRF	STEELE (1971)
	106	139	XRF	BEASLEY (1972)
	75 (3)	135 (3)	OS(DR)	THOMPSON (1972)
	140	140	OS	CHAMP and BENDER (1973)
	122	140	XRF	MURAD (1973)
	97.8	151	Photom.	KIRIYAMA and KURODA (1974)

(Continued)

	JG-1	JB-1	Method	References
Zr	115	215	XRF	GAGNON (1974)
	160	360	NAA	RANDLE (1974)
	106 (2)	143.5 (2)	PAA	SATO <i>et al.</i> (1974)
	111 (av.)	173 (av.)		
	111 (avc.)	153 (avc.)		

Table 6. *Strontium isotopic ratios*

	JG-1	JB-1	Method	References
⁸⁷ Sr/ ⁸⁶ Sr norm.	0.7115 (2)	0.7047	M	TAKEUCHI and SHIMA, MAS. (1968)
	0.7116 (2)	0.7047	M	UEDA, N. (1968)
	0.7117 (3)	0.7053 (2)	M	YAMAGUCHI (1968)
	0.7117 (2)	—	M	SATO <i>et al.</i> (1969)
	0.7113 (2)	0.7043	M	SHIBATA (1970)
	0.7118	0.7056*	M	KURASAWA (1970)
	0.7115	—	M	ISHIZAKA (1971)
	0.7114 (2)	0.7043	M	SHIBATA and ADACHI (1972)
	0.7108	0.7043 (2)	M	SHIRAHASE (1974)
	0.7111 (2)	—	M	MAHON (1974)
	—	0.7046	M	KURASAWA (1974)
	—	0.7044	M	FUJIMAKI (1974)
	0.7114 (av.)	0.7046 (av.)		

* : This is omitted from the calculation of the average as it has been superseded by the revised value (KURASAWA, 1974).

REFERENCES

- ADAMS, J. A. S. (1972) Private communication, Rice University, Houston, Texas, U.S.A.
- AKAIWA, H., TAZIMA, E. and TODOKORO, A. (1971) Private communication, Gunma University, Kiriu, Gunma, Japan.
- AKAIWA, H. and AIZAWA, S. (1973) Behavior of fluorine during sedimentary processes - Fluorine contents of sedimentary rocks from Tomioka, southern Gunma Prefecture, Japan -. *Geochem. J.* 7, 1-9.
- AKAIWA, H., KAWAMOTO, H. and KONDO, H. (1974) Extractive spectrophotometric determination of vanadium (V) by using the combination of 1-butanol and PAR. *Japan Analyst (Bunseki Kagaku)* 23, 402-406 (in Japanese with English abstract).
- ANDO, A. (1967) A new silicate rock standard, JG-1 issued from the Geological Survey of Japan. *Geochem. J.* 1, 155.
- ANDO, A. (1971) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- 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.* 5, 151-164.
- BEASLEY, P. H. (1972) Private communication, Department of Geophysics and Geochemistry, The Australian National University, Canberra, Australia.
- BOUVIER, J. L. (1970) Private communication, Geological Survey of Canada, Ottawa, Canada.
- BRENNER, I. B. (1973) Private communication, Geological Survey of Israel, Jerusalem, Israel.
- 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* **37**, 1189–1200.
- FRIESE, D. C. G. (1972) Quoted in SCHMIDT, K. (1972).
- FUJIMAKI, H. (1974) Private communication, Geological Institute, University of Tokyo, Tokyo, Japan.
- FUKASAWA, T. (1973) Private communication, Faculty of Engineering, Yamanashi University, Kofu, Japan.
- GAGNON, J. (1974) Private communication, Service Analyse et Contrôle, Complexe Scientifique, Ste-Foy, Qué. Canada.
- GOVINDARAJU, K., MEVELLE, G. and CHOUARD, C. (1971) Direct atomic absorption determination of rubidium on pulverized silicate rock samples. *Chem. Geol.* **8**, 131–137.
- HASHIMOTO, T. (1969) Private communication, Kyoto University, Kyoto, Japan.
- HATTORI, H. and SHIBATA, K. (1967) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- HATTORI, H. and SHIBATA, K. (1969) Quantitative analysis of Rb and Sr in rocks by X-ray fluorescence spectrometry. *Bull. Geol. Surv. Japan* **20**, 51–76 (in Japanese with English abstract).
- HAYASE, I. (1968) Private communication, Kyoto University, Kyoto, Japan.
- HAYATA, T. (1974) Chemical analysis of geochemical standard sample JB-1 (1). *Nagasaki-ken Chigakukaishi* No. 21, 19–21 (in Japanese).
- HUYSMANS, K. (1973) Private communication, Institut voor Nucleaire Wetenschappen, Ruks-universiteit, Gent, Belgium.
- HUYSMANS, K. (1974) Private communication, Institut voor Nucleaire Wetenschappen, Ruks-universiteit, Gent, Belgium.
- IKEDA, K. (1970) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- IKEDA, N. (1972) Private communication, Tokyo Kyoiku University, Tokyo, Japan.
- ISHIZAKA, K. (1971) A Rb-Sr isotopic study of the Ibaragi granitic complex, Osaka, Japan. *J. Geol. Soc. Japan* **77**, 731–740.
- ISOZAKI, A., YOSHIDA, M., UTSUMI, S. and IWASAKI, I. (1973) The boron content of volcanic rocks in Japan. *Nippon Kagaku Kaishi* **22**, 1896–1904 (in Japanese with English abstract).
- KANAYA, H. (1970, 1971) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- KATO, T., KITAZUME, E. and SUZUKI, N. (1974) Private communication, Tohoku University, Sendai, Japan.
- KATO, Y. (1970) Total Fe₂O₃ and Zn contents in the geochemical standards JB-1 and JG-1 determined by atomic absorption spectrometry. *J. Jap. Assoc. Min. Pet. Econ. Geol.* **64**, 31–34 (in Japanese with English abstract).
- KAWABE, I. (1974) Transition metal contents of Paleozoic geosynclinal basalts in Southwest Japan and their geological significance. *J. Geol. Soc. Japan* **80**, 539–554 (in Japanese with English abstract).
- KIRIYAMA, T. and KURODA, R. (1974) Ion-exchange separation and spectrophotometric determination of zirconium, thorium and uranium in silicate rocks with arsenazo III. *Anal. Chim. Acta* **71**, 375–381.
- KURASAWA, H. (1968) A new silicate rock standard, JB-1 issued from the Geological Survey of Japan. *Geochem. J.* **2**, 185.

- KURASAWA, H. (1970) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- KURASAWA, H. (1974) 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.
- MASUDA, Y. and YAGI, S. (1971) Private communication, University of Osaka Prefecture, Sakai, Japan.
- MIYAKE, Y. and SUGIMURA, Y. (1967) Private communication, Tokyo Kyoiku University and Meteorological Research Institute, Tokyo, Japan.
- MIYAKE, Y., SUGIMURA, Y. and HIRAO, Y. (1970) Private communication, Tokyo Kyoiku University and Meteorological Research Institute, 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.
- MURAD, E. (1973) Determination of trace elements in unfused rock and mineral samples by X-ray fluorescence. *Anal. Chim. Acta* **67**, 37–53.
- NAGASAWA, H. (1971) Private communication, NASA, Goddard, Maryland, U.S.A.
- NAGURA, M. and IIDA, C. (1968) Atomic absorption spectrophotometric determination of cobalt, nickel, lead and copper in silicates with the absorption tube technique. *Japan Analyst (Bunseki Kagaku)* **17**, 1513–1518 (in Japanese with English abstract).
- NAKAMURA, N. and MASUDA, A. (1971) Private communication, Science University of Tokyo, Tokyo, Japan.
- NISHIMURA, S. (1969) Radium and uranium content of standard rocks. *Chem. Geol.* **5**, 139–141.
- NISHIMURA, S. (1970) The determination of uranium content of standard rocks by fission track registration in muscovite. *Radioisotopes* **13**, 194–196 (in Japanese with English abstract).
- OAKLEY, P. J. (1973) Quoted in RANDALL, B. A. O. (1973).
- OHTA, K. (1972) Private communication, Tokyo Coal and Mineral Laboratory, Tokyo, Japan.
- OZAWA, T., YOSHIDA, M., NAGASHIMA, S., IWASAKI, I. and ARIKAWA, Y. (1972) The sulfur content of igneous rocks in Japan. Annual Meeting Geochem. Soc. Japan, Abst. 13B10, 122 (in Japanese).
- OZIMA, M., KANEOKA, I., KANO, M., KINOSHITA, K., OHNAKA, N., NAGATA, T. and KARASAWA, H. (1968) Paleomagnetism and K-Ar ages of successive lava flow (2) - Kita-matsuura basalt, Kyushu, Japan. *J. Geomag. Geoelect.* **20**, 85–92.
- PRICE, V. (1969) Private communication, Furman University, Greenville, South Carolina, U.S.A.
- RANDALL, B. A. O. (1972) Private communication, the University of Newcastle upon Tyne, Newcastle, England.
- RANDLE, K. (1974) Some trace element data and their interpretation for several new reference samples obtained by neutron activation analysis. *Chem. Geol.* **13**, 237–256.
- RUBEŠKA, I. (1972) Private communication, Geological Survey of Czechoslovakia, Prague, Czechoslovakia.
- RUBEŠKA, I. (1973) The determination of barium in gas shielded flames. *Atom. Absorption Newsletter* **12**, No. 2, 33–36.
- RUBEŠKA, I. (1974) Private communication, Geological Survey of Czechoslovakia, Prague,

Czechoslovakia.

- SAKURAMOTO, Y. (1973) Private communication, Osaka City University, Osaka, Japan.
- SATO, N., KATO, T. and SUZUKI, N. (1974) Multielement photon activation analysis of rock materials with 30 MeV bremsstrahlung. *Radiochim. Acta* **19**, 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.* **17**, 522–529.
- SCHAFER, M. (1973) Private communication, Victoria University of Wellington, Wellington, New Zealand.
- SCHMIDT, K. (1972) Private communication, Zentrales Geologisches Institut, Berlin, DDR.
- SEKINE, S. and MOCHIZUKI, T. (1968) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- SEN GUPTA, J. G. (1968) Private communication, Geological Survey of Canada, Ottawa, Canada.
- SHIBATA, K. (1968) K-Ar age determinations on granitic and metamorphic rocks in Japan. *Geol. Surv. Japan, Report No. 227*, 1–71.
- SHIBATA, K., NOZAWA, T. and WANLESS, R. K. (1970) Rb-Sr geochronology of the Hida metamorphic belt, Japan. *Can. J. Earth Sci.* **7**, 1383–1401.
- SHIBATA, K. and ADACHI, M. (1972) Rb-Sr and K-Ar geochronology of metamorphic rocks in the Kamiaso conglomerite, Central Japan. *J. Geol. Soc. Japan* **78**, 265–271.
- SHIBATA, K. and UCHIUMI, S. (1974) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- SHIMA, MAKOTO (1968) Private communication, Institute of Physical and Chemical Research, Yamato-cho, Saitama, 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.
- 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 Research Institute, Tokai, Ibaragi, Japan.
- TANAKA, TAMOTSU and IIDA, C. (1969) Atomic absorption spectrophotometric determination of lead by absorption tube technique. *Japan Analyst (Bunseki Kagaku)* **18**, 492–496 (in Japanese with English abstract).
- TANAKA, TSUYOSHI and MASUDA, A. (1971) Private communication, Geological Survey of Japan and Science University of Tokyo, Kawasaki and Tokyo, Japan.
- TANAKA, TSUYOSHI (1974) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- TANIGUCHI, S. and OKADA, S. (1968) Private communication, Radiation Center of Osaka Prefecture, Sakai, Japan.
- TERADA, K. (1974) Private communication, Kanazawa University, Kanazawa, Japan.
- TERADA, K., TERASHIMA, K. and KIBA, T. (1972) Neutron activation analysis of selenium and osmium in rocks and sediments by direct evolution with the condensed phosphoric acid reagents. Annual Meeting, Geochem. Soc. Japan, Abst. 13B11, 123 (in Japanese).
- TERADA, K. and HIRAKAWA, S. (1974) Determination of chlorine in rocks by direct evolution with the condensed phosphoric acid - Chlorine contents of the standard rocks, JG-1 and JB-1 -. Annual Meeting, Geochem. Soc. Japan, Abst. C9, 131 (in Japanese).

- TERADA, K., Ooba, T. and KIBA, T. (1975) Separation and determination of selenium in rocks, marine sediments and plankton by direct evolution with the bromide-condensed phosphoric acid reagent. *Talanta* **22**, 41–49.
- TERASHIMA, S. (1970) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- TERASHIMA, S. (1971a) Atomic absorption analysis of minor elements in silicates. *Japan Analyst (Bunseki Kagaku)* **20**, 321–326 (in Japanese with English abstract).
- TERASHIMA, S. (1971b) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- TERASHIMA, S. (1973a) Atomic absorption analysis of beryllium and vanadium in rocks. *Japan Analyst (Bunseki Kagaku)* **22**, 1317–1323 (in Japanese with English abstract).
- TERASHIMA, S. (1973b) Atomic absorption analysis of Be, V, Ba and Rb in rocks and flame emission analysis of Rb. *Bull. Geol. Surv. Japan* **24**, 469–485 (in Japanese with English abstract).
- TERASHIMA, S. (1974a) Spectrophotometric determination of chlorine and fluorine in the standard silicate rocks. *Bull. Geol. Surv. Japan* **25**, 175–179.
- TERASHIMA, S. (1974b) Atomic absorption analysis of micro-amounts of arsenic and antimony in silicates by the arsine and stibine generation method. *Japan Analyst (Bunseki Kagaku)* **23**, 1331–1337 (in Japanese with English abstract).
- TERASHIMA, S. (1974c) Private communication, Geological Survey of Japan, Kawasaki, Japan.
- THOMPSON, G. (1972) Private communication, Woods Hole Oceanographic Institute, Woods Hole, Massachusetts, U.S.A.
- TODA, N. (1973) Private communication, Nihon Cement Research Laboratory, Tokyo, Japan.
- TOGASHI, Y. (1972) Private communication, Geological Survey of Japan, Tokyo, Japan.
- TOMURA, K., HIGUCHI, H., ONUMA, N. and HAMAGUCHI, H. (1968) Rapid determination of dysprosium in rock samples by neutron activation analysis with a Ge(Li) detector after chemical separation. *Anal. Chim. Acta* **42**, 389–395.
- 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 group separation. *ibid.* **43**, 523–526.
- UCHIDA, S. (1973) Private communication, Nihon cement Research Laboratory, 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.* **61**, 35–39 (in Japanese with English abstract).
- 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.
- YAMADA, J., IIDA, C. and YAMASAKI, K. (1969) Atomic absorption spectrophotometric determination of trace amount of cadmium in silicates with the absorption tube technique. *Japan Analyst (Bunseki Kagaku)* **18**, 1088–1092 (in Japanese with English abstract).
- YAMADA, J., IIDA, C. and YAMASAKI, K. (1970) Atomic absorption determination of cadmium in silicates with the absorption tube technique combined with a ring burner. *ibid.* **19**, 1259–1263 (in Japanese with English abstract).
- YAMAGUCHI, M. (1968) Private communication, Kyushu University, Fukuoka, Japan.