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JLk-1, JLs-1 and JDo-1, GSJ rock reference samples of the "Sedimentary rock series"

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Abstract : Three new rock reference samples of the "Sedimentary rock series" have been prepared by the Geological Survey of Japan (GSJ), in February 1987. They are JLk-1 fresh water lake sediment (Lake Biwa, Shiga Prefecture), JLs-1 limestone (Garo Mine, Nihon Cement Co. Ltd., Hokkaido) and JDo-1 dolomite (Yoshizawa Lime Ind. Co. Ltd., Kuzuu, Tochigi Prefecture).

Analytical data for major and minor constituents, received by March 1989 on these three GSJ rock reference samples of the "Sedimentary rock series" have been preliminarily compiled. Based on the data available (communicated and published), grand means, medians, standard deviations (S.D.) have been derived for some constituents. First approximate values for major and minor constituents have been proposed after the evaluation of the statistical results.

Introduction

The Geological Survey of Japan (GSJ) has been processing some series of rock reference samples for major, minor and trace elements, isotopic compositions and isotopic ages.

The first series of two samples JG-1 granodiorite and JB-1 basalt was issued in 1967 and 1968. Processing of the second series of GSJ rock reference samples, "Igneous rock series", started in April 1981 and was completed in March 1986. Fifteen new rock reference samples are added to the list of GSJ analytical program of rock reference samples. The 1986 values for major and minor constituents for this second series of samples as well as for the first series of samples JG-1 and JB-1 have been reported (ANDO *et al.*, 1987).

Processing of the third series of GSJ rock reference samples, "Sedimentary rock series", started in April 1986 and the first issue of three samples of this series was completed in February 1987, which are JLk-1 fresh water lake sediment, JLs-1 limestone and JDo-1 dolomite. Some other samples of this series (slate, chert, and stream sediments) have also been issued recently and they will be reported elsewhere.

This is the first compilation of major and minor elements on JLk-1, JLs-1 and JDo-1, GSJ rock reference samples of the "Sedimentary rock series". Based on the data available (communicated and published) received by March 1989, first reference values have been proposed by the evaluation of statistical results.

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Table 1 Sampling locations.

Reference sample		Sampling point
JLk-1	Lake sediment	Lake Biwa, Shiga Prefecture Latitude: 35° 14' 42" N Longitude: 136° 03' 14" E
JLs-1	Limestone	Hekireji, Kamiiso-cho, Kamiiso-gun, Hokkaido (Garo Mine, Nihon Cement Co. Ltd.) Latitude: 41° 52' 26" N Longitude: 140° 34' 20" E
JDo-1	Dolomite	Nagikubo, Kuzuu-machi, Aso-gun, Tochigi Prefecture (Yoshizawa Lime Industry Co. Ltd.) Latitude: 32° 27' 16" N Longitude: 139° 36' 41" E

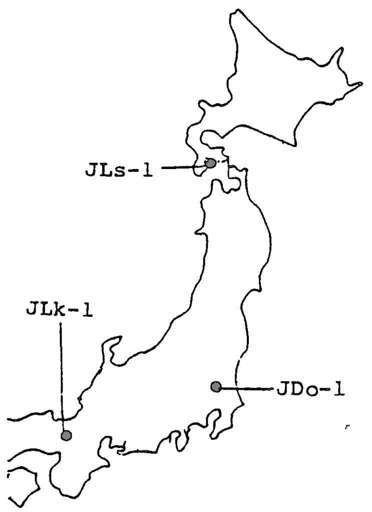


Fig. 1 Locality of JLk-1, JLs-1 and JDo-1.

Note on the samples

The rock reference samples of sedimentary rock series were sampled at the largest lake in Japan and quarries of active mines, respectively. Their locations are shown in Table 1 and Figure 1.

JLk-1, fresh water lake sediment was collected at Lake Biwa, Shiga Prefecture. Sampling point is about 3.8 km off the shore of Takashima-cho, where the depth of water is 63 m (Fig.2). The surface sediment of the bottom of 0–20 cm was sampled, for which Smith-McIntyre grab sampler was used. Sampling was carried out in support of the research project entitled "Sedimentation of polluted lake sediment" (INOUCHI *et al.*, 1986), in August 1986, by TERASHIMA, S. and INOUCHI, Y. About 210 kg of watery sediment was collected.

JLs-1, dark grey limestone was collected at the quarry of Hekireji Deposit (450 m L), Garo Mine (Nihon Cement Co. Ltd.), Kamiiso-cho, Hokkaido (about 20 km west of Hakodate). A geological description on Garo Mine has been written by SAITO and KOIKE (1983). The age of the upper member of Kamiiso limestone is not determined clearly, however it has been suggested as Upper Triassic, from the observation of conodonts (SAKAGAMI *et al.*, 1969). About 300 kg of rock pieces was collected in June 1986, by IGARASHI, T. Geological sketch map showing sampling point is given in Figure 3.

JDo-1, grey dolomite was collected at the quarry of middle dolomite layer (120 m in thickness), Nagikubo, Mitsumine district

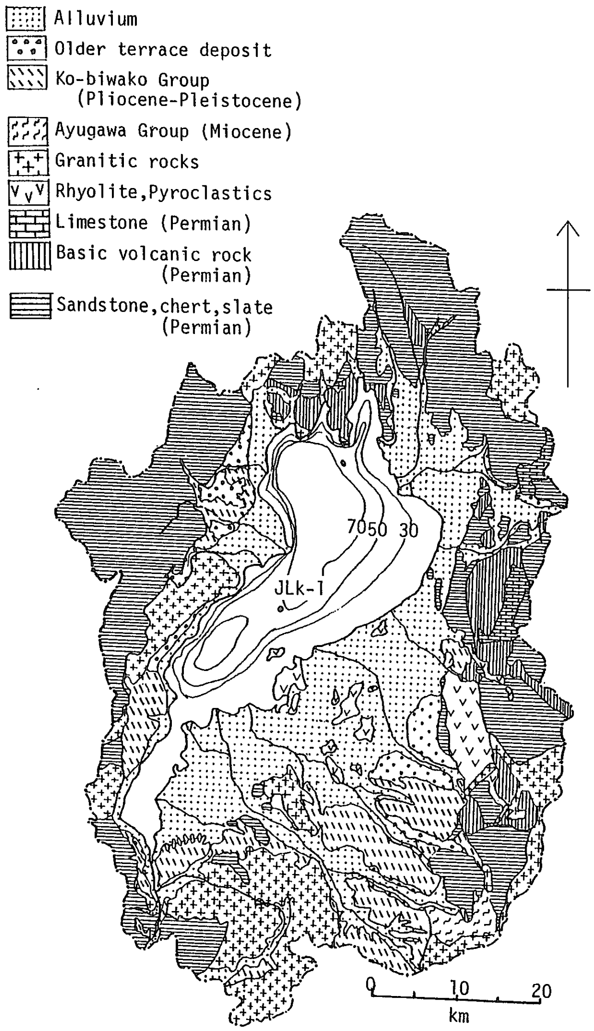
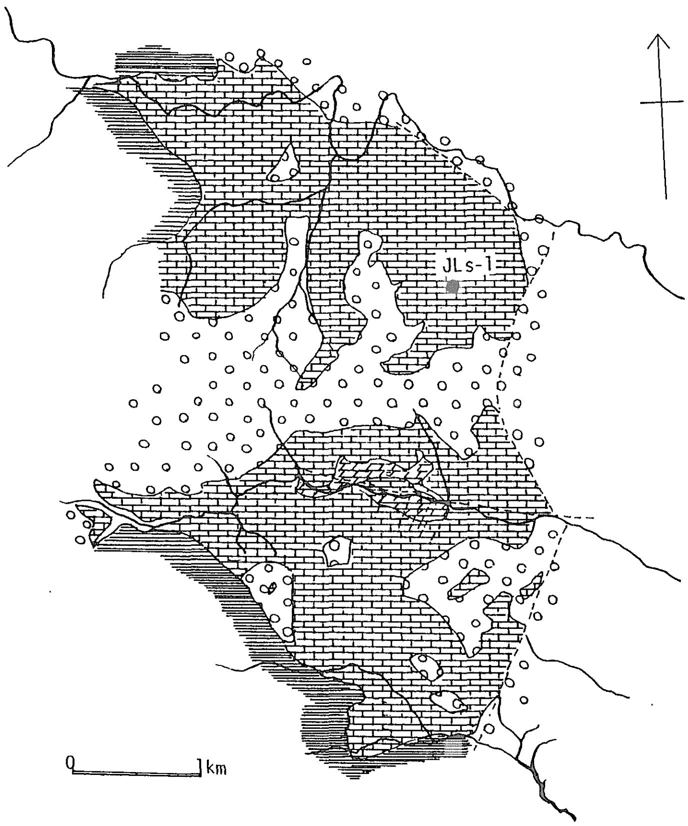


Fig. 2 Geological sketch map of Shiga Prefecture, showing sampling point of JLk-1 at Lake Biwako. Modified from MATSUOKA (1978).

(Yoshizawa Lime Industry Co. Ltd.), Kuzuu-machi, Tochigi Prefecture. A geological description on Kuzuu carbonate rocks has been written by WADA (1983). Permian carbonate rocks at the Kuzuu area consist of three layers: lower limestone, middle dolomite and upper limestone (total thickness 300 m). Major and minor elements on Kuzuu carbonate rocks have been studied by FUJINUKI *et al.* (1982) and AIZAWA and AKAIWA (1987) in detail. Geological sketch map showing sampling point is given in Figure 4.

In the geological sheet map "Tochigi" (scale 1 : 50,000, FUJIMOTO, 1961), the distribution of Kuzuu carbonate rocks is clearly figured like a horse's hoof in shape. About 300 kg of rock pieces was collected from the nearly middle horizon of the dolomite layer, in June 1986, by OKAI, T. and ANDO, A.



Legend

Neogene sandstone,mudstone,conglomerite and tuff
Paleogene sandstone,mudstone,conglomerite and tuff
Late Triassic limestone
Late Triassic dolomite
----- fault

Fig. 3 Geological sketch map of Garo limestone mining district (Nihon Cement Co.), showing location of JLs-1. Modified from SAITO and KOIKE (1983)

Processing of samples

About 210 kg of wet JLk-1 sample ($H_2O\pm$: 69.3 %) was spread out in thin plastic containers to be dried by an electric fan under room temperature until the weight becomes to constant. After 43 days, about 73.5 kg of dried sample ($H_2O\pm$: 12.3 %) was obtained. Then the sample was milled in a high-alumina lined ball mill of 22 liter capacity (for about 100 kg of silicate materials) with flint balls, for about 10 hours. Finally about 70 kg of fine powdered sample ($H_2O\pm$: 9.9 %) was obtained. During grinding process 2.4 % of water was lost.

Cleaned rock pieces (JLs-1 and JDo-1, about 100 kg each) were broken with a sledge-hammer to 5 to 10 cm ; crushed to 1-2 cm pieces with a Jaw crusher (Retsch type BBZ/A) ; milled in a high-alumina lined ball mill with balls made of the rock sample to be

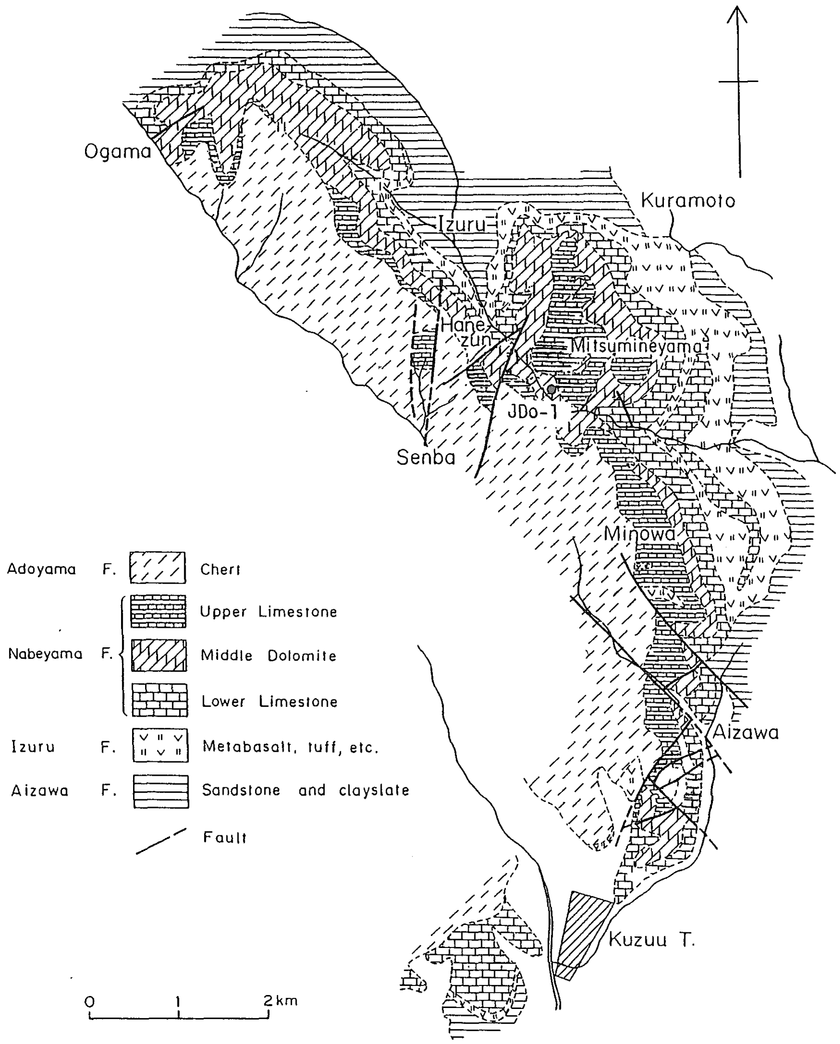


Fig. 4 Geological sketch map of Kuzuu-machi, Tochigi Prefecture, showing location of JDo-1. Modified from FUJINUKI *et al.* (1982).

processed, for about 48 hours ; screened with a 100 mesh steel sieve (JLk-1 was also screened) ; mixed well before packing in glass bottles.

JLk-1 of about 70 kg was prepared with the final packaging in about 900 bottles containing 70 g each. JLs-1 and JDo-1 were prepared in about 100 kg, with the final packaging in about 1000 bottles cotaining 100 g each.

Statistical evaluation of the data

We received 29 reports from 17 laboratories on 20 major constituents and 36 minor elements for GSJ JLk-1, JLs-1 and JDo-1 samples. All reported data were analyzed "on received basis" (not on dry basis). Code for analytical method is given in Table 2. All reported data were tabulated in Appendix with references for individual data.

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Table 2 Code for analytical methods.

Code	Method
AA	Atomic absorption spectrometry
Calc.	Calculation
com-IR-abs.	Combustion infrared absorption spectrometry
Distil	Distillation
Fluo.	Fluorometry
Grav.	Gravimetry
IC	Ion chromatography
ICP	Inductively coupled plasma optical emission spectrometry
INAA	Instrumental neutron activation analysis
Photom	Spectrophotometry
Vol.	Volumetry
XRF	X-ray fluorescense
γ cntg.	Gamma-ray counting

data available (communicated and published) is more than five, mean, median and standard deviation (S. D.) have been calculated with the exception of some major elements (Table 3). Because number of available analytical data is still a few, the mean values are not yet certified and to be considered as only preliminary for all elements.

H_2O- concentrations of these samples are 3.79 % (JLk-1), 0.10 % (JLs-1) and 0.15 % (JDo-1). Accordingly, the analytical data can be converted to "on dry basis" by multiplying the following factors on "received basis" data : 1.039 (JLk-1), 1.0010 (JLs-1) and 1.0015 (JDo-1).

DTA and electron microscope observation

The differential thermal analysis (DTA) for the standard samples has been carried out by SUDO, S. Obtained thermal gravity (TG) and DTA curves for JLk-1, JLs-1 and JDo-1 are shown in Figures 5-7, respectively.

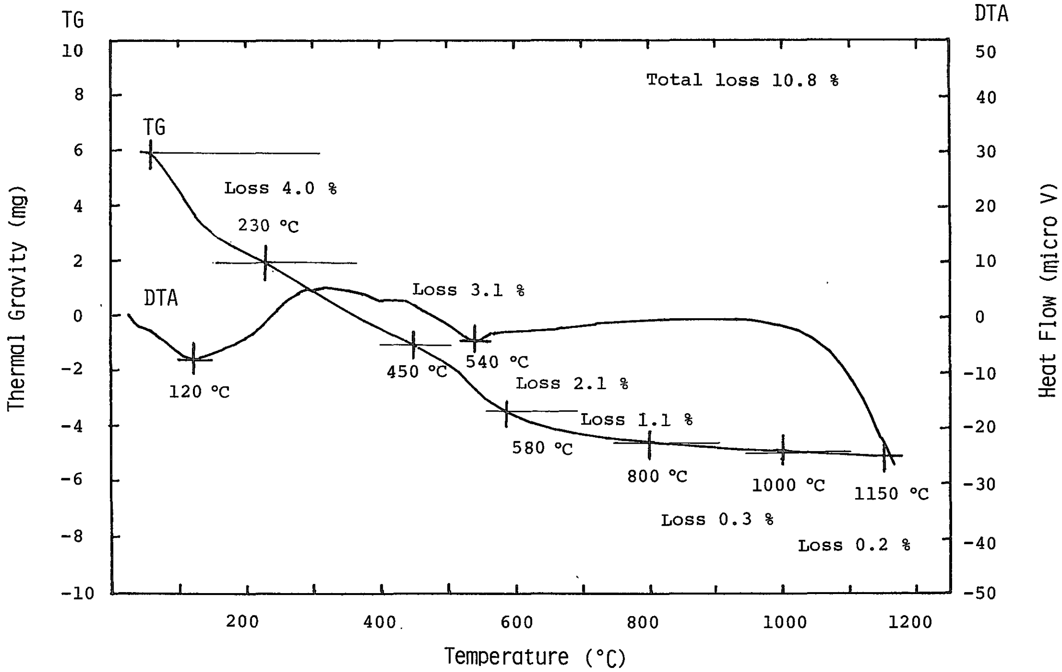

Fig. 5 TG-DTA curve for JLk-1. Weight of sample : 100 mg, elevating temperature rate : 20 °C/min. instrument : Rigaku Denki, thormoflex type 9500.

Table 3 Means, median and standard deviation.

JLk-1 Major constituent (%)

Component	Mean	S.D.	number	Median	Range
SiO_2	57.50	0.928	9	57.08	56.84 - 59.31
TiO_2	0.663	0.031	11	0.66	0.62 - 0.73
Al_2O_3	16.81	0.264	11	16.76	16.54 - 17.48
Fe_2O_3	4.52	0.642	4	4.44	3.83 - 5.37
FeO	2.14	0.266	5	2.1	1.79 - 2.52
MnO	0.265	0.017	12	0.26	0.24 - 0.296
MgO	1.79	0.100	10	1.76	1.71 - 2.05
CaO	0.686	0.033	11	0.68	0.64 - 0.73
Na_2O	1.030	0.087	14	1.05	0.78 - 1.105
K_2O	2.822	0.124	14	2.85	2.53 - 3.08
P_2O_5	0.213	0.023	9	0.21	0.18 - 0.27
H_2O^+	6.31	0.357	4	6.25	5.95 - 6.80
H_2O^-	3.71	0.332	5	3.71	3.30 - 4.17
T-C	1.50		2		1.48 - 1.52
SO_3	0.206	0.126	3	0.275	0.06 - 0.282
$T\text{-}Fe_2O_3$	6.98	0.288	13	6.96	6.63 - 7.45
LOI	11.35	1.18	5	11.92	9.31 - 12.18

JLk-1 Minor element (ppm)

Element	Mean	S.D.	number	Median	Range
Ba	586	55	8	575	527 - 655
Ce	89.4	6.455	7	92	79 - 95.7
Co	16.6	3.47	10	17.85	8 - 19.1
Cr	74.15	11.3	10	70.5	61 - 96
Cs	11.0	1.63	5	11.8	8.6 - 12.3
Cu	60.9	4.1	5	61	57 - 67.5
Eu	1.35	0.15	5	1.28	1.26 - 1.62
Hf	3.97	0.56	6	4.01	3.4 - 4.9
La	41.7	2.77	7	41.7	38 - 47
Ni	34.86	4.14	7	33	30 - 41
Pb	42.42	4.57	6	41.3	38 - 50
Rb	145.8	14.18	6	147	121 - 165
Sc	15.45	1.3	7	15.9	13 - 16.2
Sm	8.17	0.80	6	8.22	7.2 - 9.5

Table 3 continued

Sr	71.75	14.577	8	69.5	58 - 105
Ta	1.40	0.365	5	1.29	1.16 - 2.05
Th	19.6	1.01	8	20	18.1 - 21
U	3.69	0.65	6	3.75	2.66 - 4.4
V	118.71	17.2	7	114	103 - 153
Zn	151.39	20.94	9	155	105 - 178
Zr	140.6	31.05	5	147	94 - 178

JLs-1 Major constituent (%)

Component	Mean	S.D.	number	Median	Range
SiO_2	0.141	0.052	10	0.115	0.08 - 0.25
TiO_2	0.004	0.004	4	0.0015	0.001 - 0.01
Al_2O_3	0.021	0.0087	10	0.02	0.0098 - 0.04
T-Fe_2O_3	0.0166	0.0029	13	0.016	0.01 - 0.02
MnO	0.0018	0.0005	8	0.002	0.001 - 0.002
MgO	0.604	0.056	12	0.605	0.52 - 0.71
CaO	55.25	0.425	12	55.18	54.56 - 56.26
Na_2O	0.027	0.037	9	0.007	0.001 - 0.1
K_2O	0.009	0.0092	10	0.0061	0.0028 - 0.03
P_2O_5	0.0361	0.01196	8	0.03	0.029 - 0.06
H_2O^+	0.155	0.049	2	0.155	0.12 - 0.19
H_2O^-	0.1	0.023	5	0.09	0.08 - 0.14
CO_2	43.70	0.43	5		42.94 - 44.02
SO_3	0.0327	0.0023	3	0.034	0.03 - 0.034
T-C	11.98		1		
LOI	43.61	0.494	6	43.765	42.61 - 43.95

JLs-1 Minor element (ppm)

Element	Mean	S.D.	number	Median	Range
Ba	503.9	161.39	7	515	207 - 749
Ce	8.18	17.61	7	1.55	0.23 - 48
Co	0.0497	0.023	5	0.054	0.0103 - 0.0703
Cr	4.204	1.156	5	4.3	3.1 - 6.
Sc	6.19	15.09	6	0.031	0.0292 - 37
Sm	0.797	1.457	5	0.185	0.026 - 3.4
Sr	285.25	43.067	8	284.5	188 - 320
Th	0.40	0.84	5	0.03	0.020 - 1.9
U	1.798	0.28	6	1.825	1.41 - 2.1
Zn	4.58	2.81	7	3.2	2.02 - 9.5

Table 3 continued

JDo-1 Major constituent (%)

Component	Mean	S.D.	number	Median	Range		
SiO_2	0.211	0.069	10	0.215	0.05	-	0.32
TiO_2	0.004	0.0044	4	0.0015	0.001	-	0.01
Al_2O_3	0.0162	0.0070	9	0.015	0.008	-	0.03
T-Fe_2O_3	0.0205	0.0056	12	0.021	0.007	-	0.03
MnO	0.0062	0.0093	9	0.0062	0.004	-	0.007
MgO	18.75	0.62	12	18.675	17.75	-	19.97
CaO	33.98	0.444	12	34.01	33.28	-	34.65
Na_2O	0.0438	0.0497	9	0.016	0.006	-	0.14
K_2O	0.00565	0.0064	8	0.003	0.0012	-	0.02
P_2O_5	0.037	0.0097	8	0.0345	0.03	-	0.06
H_2O^+	0.33	0.062	3	0.31	0.28	-	0.40
H_2O^-	0.14	0.0255	5	0.15	0.10	-	0.16
CO_2	46.57	0.57	5	46.87	45.65	-	47.01
SO_3	0.023	0.0042	3	0.022	0.02	-	0.028
T-C	12.76		1				
LOI	46.49	0.82	6	46.75	44.86	-	47.1

JDo-1 Minor element (ppm)

Element	Mean	S.D.	number	Median	Range		
Ce	2.996	1.15	5	2.47	2.2	-	4.98
Cr	9.14	2.739	5	7.49	7.2	-	13.5
Eu	0.178	0.05	5	0.173	0.131	-	0.259
La	7.92	0.546	6	8	7	-	8.52
Sc	3.616	8.517	6	0.1435	0.123	-	21
Sm	1.26	0.865	5	0.89	0.807	-	2.8
Sr	116.38	14.232	8	118.5	85	-	134
U	0.88	0.157	6	0.92	0.67	-	1.04
Zn	34.45	4.829	8	35.3	23.5	-	39.5

Abbreviation for Table 3: T, total; LOI, Loss on ignition.

DTA curve for JLk-1 (Fig. 5) : An endothermic change was observed, minus peak maximum at about 120 °C and 540 °C, owing to the evaporation of layer water and crystal water. An exothermic change was also observed, plus peak maximum at about 300 °C, owing to the combustion of organic materials.

DTA curve for JLs-1 (Fig. 6) : An endothermic change was observed, minus peak maximum at 946 °C, owing to the decomposition of calcium carbonate ($CaCO_3 \rightleftarrows CaO + CO_2$).

DTA curve for JDo-1 (Fig. 7) : Two endothermic changes were observed, the first minus peak maximum at 752 °C, owing to the decomposition of magnesium carbonate

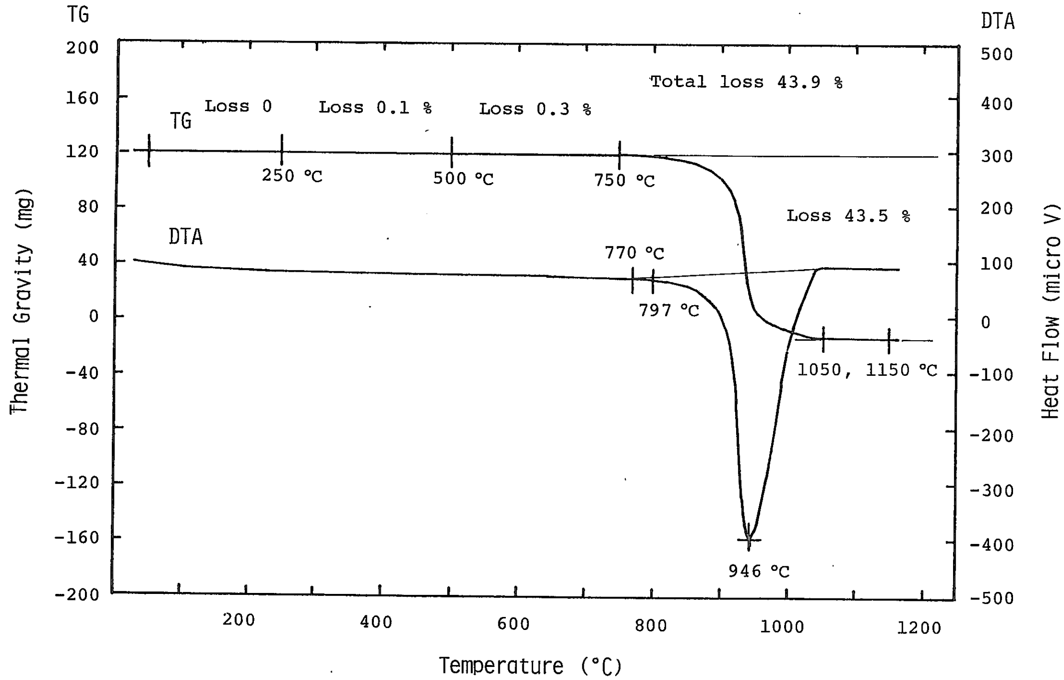

Fig. 6 TG-DTA curve for JLs-1. Weight of sample : 300 mg, elevating temperature rate : 20 °C/min.

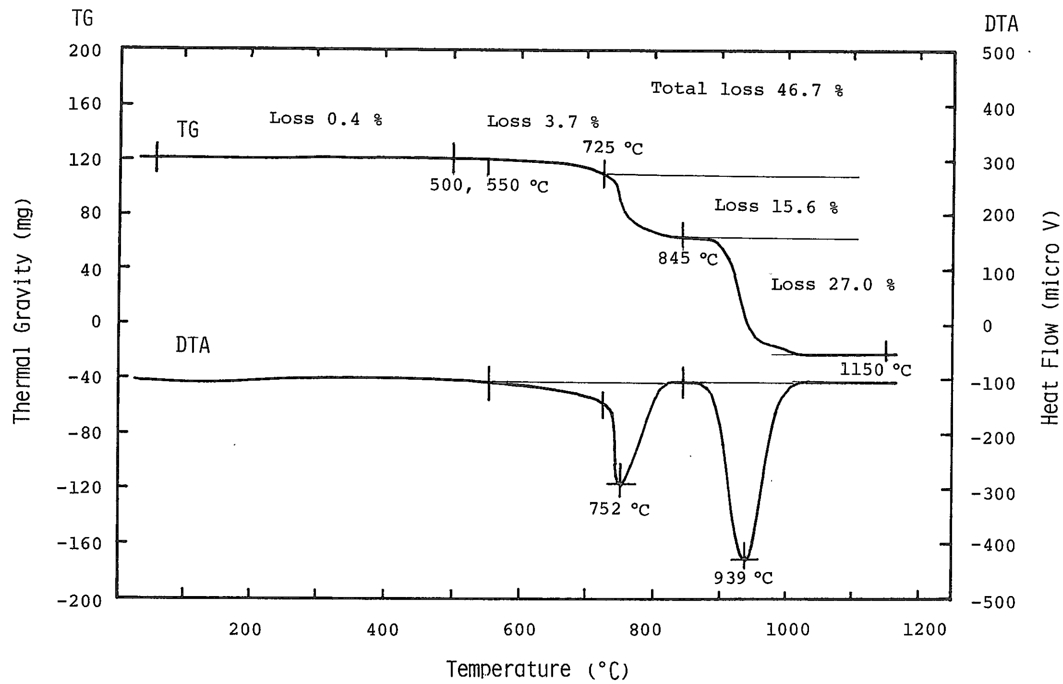

Fig. 7 TG-DTA curve for JDo-1. Weight of sample : 300 mg, elevating temperature rate : 20 °C/min.

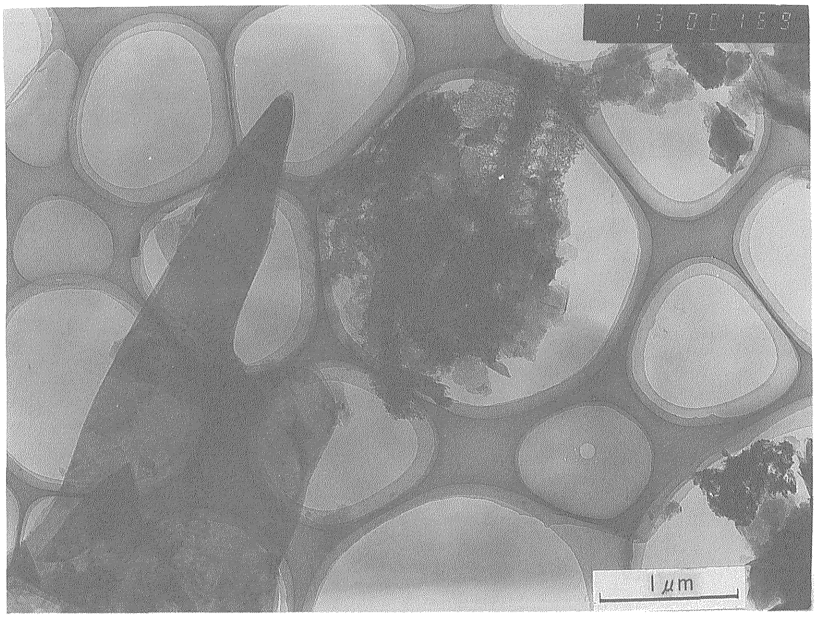

Fig. 8 Skeletons of diatoms (center) and a thin plate of mica (left). Instrument : JEOL 100 C transmission electron microscope.

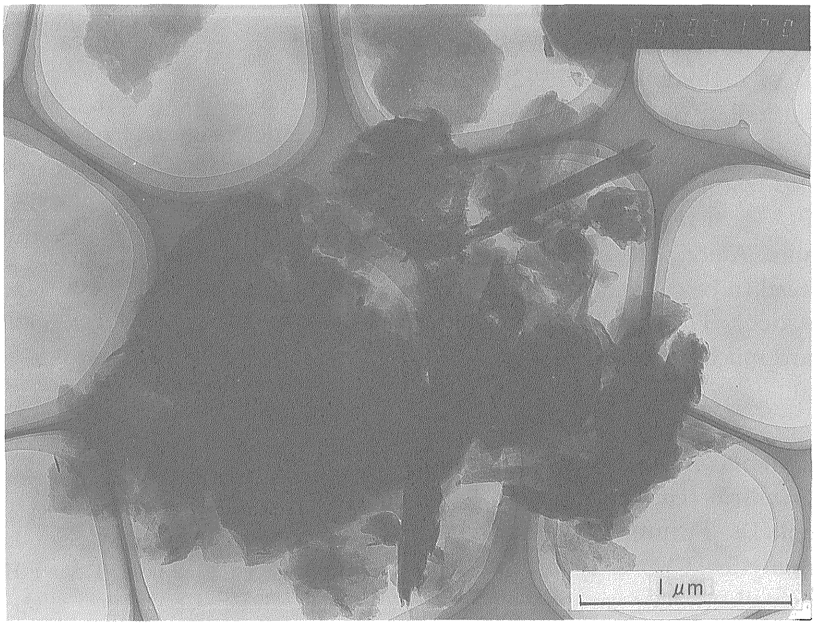

Fig. 9 Halloysite tubes and irregular thin plates of montmorillonite.

($MgCO_3 \rightleftarrows MgO + CO_2$), and a second minus peak maximum at 939 °C, owing to the decomposition of calcium carbonate. Mineral composition of JDo-1 is calculated from analytical results as $CaMg(CO_3)_2$: 84.5 % and $CaCO_3$: 15.5 %.

The clay fractions of JLk-1 have been studied with a JEOL 100C transmission elec-

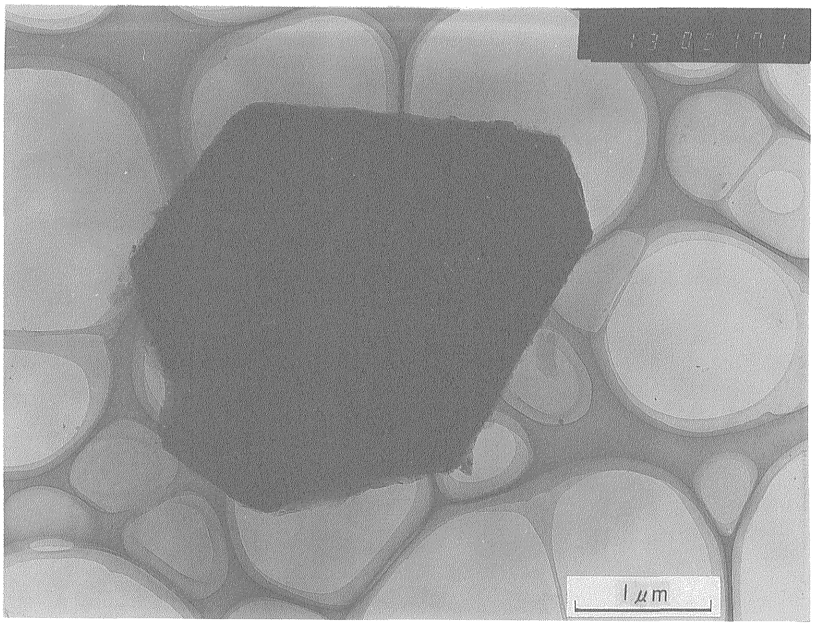

Fig. 10 A hexagonal crystal of mica.

tron microscope at an accelerating voltage of 100 kV by MARUMO, K. Features identifiable in transmission electron micrographs are: (1) skeletons of diatoms (Fig. 8), (2) mica crystals recognized by their well-defined hexagonal habit (Fig. 10) and thin plates with sharply defined edges (Fig. 8), (3) halloysite tubes (Fig. 9), (4) irregular thin plates of montmorillonite. Among these features, (1), (2) and (3) tend to be common in the coarse (1-2 μm) fractions. The thin plates of montmorillonite are much increased in fine (<0.2 μm) material.

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地質調査所（GSJ）発行の岩石標準試料“堆積岩シリーズ”，JLk-1, JLs-1 および JDo-1 について

安藤 厚・岡井貴司・井内美郎・五十嵐俊雄
須藤定久・丸茂克美・伊藤司郎・寺島 滋

要 旨

地質調査所（GSJ）岩石標準試料“堆積岩シリーズ”の第一陣として下記の 3 試料を調製（1987 年 2 月）発行した.

JLk-1 湖底堆積物，滋賀県琵琶湖，高島町沖合 3.8 km，水深 63 m 地点の湖底表層堆積物（0-20 cm）．スミス・マッキンタイヤー式採泥器を使用．風乾試料．

JLs-1 石灰岩，北海道上磯郡上磯町，日本セメント株式会社峩朗（がろう）鉱山，戸切地（へきれじ）鉱床 450 mL において採取．上磯石灰岩の地質時代は未詳であるが，コノドント等の研究により，後期三畳紀の可能性のあることが示唆されている．

JDo-1 ドロマイト，栃木県安蘇郡葛生（くずう）町，吉澤石灰工業株式会社，三峯地区名木久保鉱床，中部ドロマイト層（厚さ約 120 m のほぼ中心の層準）より採取．同地域には葛生町を中心として，二畳系に属する石灰岩，ドロマイトが馬蹄状に広く分布している．

これらの 3 試料について，主成分，微量成分および同位体組成等について国際共同分析を進めている．1989 年 3 月迄に，17 研究機関から 29 件の主・微量成分定量結果の報告を受けた（定量結果総数 1,134），保証値を決めるには分析データ数がまだ不充分な段階であるので，上記の定量結果をそのまま表示し，若干の統計的な検討を加えた．

併せて，上記 3 試料についての DTA（示差熱分析）測定結果と，JLk-1 の電子顕微鏡による観察結果を例示した．

（受付：1989 年 7 月 13 日；受理：1989 年 9 月 14 日）

Appendix

Table A-1 Analytical data with reference for individual data.

Major	JLk-1			JLs-1			JDo-1		
	%	Method	Code	%	Method	Code	%	Method	Code
SiO_2	56.84	ICP	B-309	0.08	XRF	B-304	0.05	XRF	B-304
	57.00	Grav.	B-229	0.11	Grav.	B-213	0.18	Grav.	B-229

Table A-1 continued

Major	JLk-1			JLs-1			JDo-1		
	%	Method	Code	%	Method	Code	%	Method	Code
	57.02	XRF	B 215	0.11	Grav.	B-228	0.20	Grav.	B-213
	57.08	XRF	B-239	0.11	Grav.	B-229	0.20	Grav.	B-228
	57.08	Grav.	B-266	0.11	Grav.	B-276	0.20	Grav.	B-276
	57.09	Grav.	B-228	0.12	XRF	B-239	0.23	XRF	B-239
	57.14	Grav.	B-227	0.16	Grav.	B-214	0.24	XRF	B-210
	58.93	XRF	B-210	0.16	Grav.	B-266	0.24	Grav.	B-214
	59.31	XRF	B-304	0.20	XRF	B-210	0.25	ICP	B-309
				0.25	ICP	B-309	0.32	Grav.	B-266
TiO_2	0.62	Photom	B-266	tr	XRF	B-210	tr	XRF	B-210
	0.64	ICP	B-309	0.001	ICP	B-214	0.001	ICP	B-214
	0.65	ICP	B-226	0.001	Photom	B-229	0.001	Photom	B-229
	0.66	ICP	B-197	<0.002	ICP	B-197	<0.002	ICP	B-197
	0.66	Photom	B-229	<0.002	Photom	B-228	<0.002	Photom	B-228
	0.66	XRF	B-239	0.002	XRF	B-304	0.002	XRF	B-304
	0.67	Photom	B-228	0.01	XRF	B-239	0.01	XRF	B-239
	0.67	XRF	B-304	<0.01	Photom	B-266	<0.01	Photom	B-266
	0.70	XRF	B-215						
	0.73	XRF	B-210						
Ti	0.38	INAA	B-308						
Al_2O_3	16.52	ICP	B-309	0.0098	Photom	B-213	0.008	Vol.	B-229
	16.45	Vol.	B-229	0.010	Vol.	B-229	0.01	XRF	B-210
	16.71	Vol.	B-266	0.02	XRF	B-210	0.010	Photom	B-213
	16.73	XRF	B-239	0.020	ICP	B-214	0.013	AA	B-228
	16.76	XRF	B-304	0.02	XRF	B-239	0.015	ICP	B-197
	16.82	XRF	B-215	<0.02	Vol.	B-266	<0.02	Vol.	B-266
	16.82	ICP	B-226	0.02	XRF	B-304	0.02	XRF	B-304
	16.86	AA	B-228	0.021	AA	B-228	0.022	ICP	B-214
	17.00	XRF	B-210	0.028	ICP	B-197	0.03	XRF	B-239
	17.48	ICP	B-197	0.04	ICP	B-309			
Al	8.8	INAA	B-308	0.0136	INAA	B-308	0.0094	INAA	B-308
T-Fe_2O_3	6.63	Photom	B-229	0.01	XRF	B-210	0.007	XRF	B-304
	6.66	XRF	B-239	0.014	INAA	B-232	0.014	INAA	B-232
	6.66	ICP	B-309	0.015	AA	B-228	0.020	AA	B-228
	6.72	XRF	B-215	0.016	ICP	B-197	0.02	XRF	B-239
	6.79	Photom	B-266	0.016	AA	B-213	0.021	ICP	B-197
	6.84	AA	B-228	0.016	ICP	B-214	0.021	AA	B-213
	6.96	INAA	B-232	0.016	Photom	B-229	0.021	Photom	B-229
	7.11	INAA	B-277	0.017	Photom	B-276	0.022	ICP	B-214
	7.20	ICP	B-226	0.02	XRF	B-239	0.022	Photom	B-276
	7.38	ICP	B-197	0.02	ICP	B-309	0.03	XRF	B-210
	7.45	XRF	B-210	0.02	XRF	B-304	<0.05	Photom	B-266
				<0.05	Photom	B-266			
Fe_2O_3	3.83	Calc.	B-229						
	4.33	Calc.	B-239						
	4.55	Calc.	B-228						
	5.37	XRF	B-304						
FeO	1.79	Vol.	B-304	<0.01	Vol.	B-229	<0.01	Vol.	B-229
	2.06	Photom	B-228	<0.1	Vol.	B-239	<0.1	Vol.	B-239
	2.1	Vol.	B-239						
	2.23	Vol.	B-266						
	2.52	Vol.	B-229						

Table A-1 continued

Major	JLk-1			JLs-1			JDo-1		
	%	Method	Code	%	Method	Code	%	Method	Code
Fe	4.92	INAA	B-287	0.0114	INAA	B-287	0.0164	INAA	B-308
	5.10	INAA	B-308	0.0137	INAA	B-308	0.0173	INAA	B-287
MnO	0.24	AA	B-266	0.001	Photom	B-229	0.004	XRF	B-304
	0.25	XRF	B-239						
	0.25	ICP	B-309	0.001	XRF	B-304	0.006	AA	B-228
	0.26	XRF	B-215	0.002	ICP	B-214	0.006	Photom	B-229
	0.26	Photom	B-229	0.002	AA	B-228	0.0062	AA	B-213
	0.27	AA	B-228	0.002	AA	B-266	0.007	ICP	B-197
	0.27	XRF	B-304	0.0021	AA	B-213	0.007	ICP	B-214
	0.28	INAA	B-277	0.0023	ICP	B-197	0.007	AA	B-266
	0.29	ICP	B-197	<0.01	XRF	B-239	<0.01	XRF	B-239
	0.296	ICP	B-226						
Mn	0.198	INAA	B-287	0.00158	INAA	B-308	0.0046	INAA	B-287
	0.200	INAA	B-308				0.0049	INAA	B-308
MgO	1.71	Grav.	B-229	0.52	Grav.	B-229	17.75	ICP	B-197
	1.71	XRF	B-239	0.53	ICP	B-309	18.24	XRF	B-210
	1.73	ICP	B-309	0.56	Vol.	B-276	18.26	Vol.	B-214
	1.75	XRF	B-215	0.57	Vol.	B-214	18.40	AA	B-228
	1.76	ICP	B-226	0.59	ICP	B-197	18.56	XRF	B-239
	1.76	AA	B-228	0.60	AA	B-266	18.63	Vol.	B-213
	1.78	ICP	B-197	0.61	XRF	B-304	18.72	Grav.	B-229
	1.80	XRF	B-210	0.62	Vol.	B-213	18.81	Vol.	B-276
	1.84	XRF	B-304	0.62	AA	B-228	18.94	ICP	B-309
	2.05	Vol.	B-266	0.64	XRF	B-210	18.96	Vol.	B-266
				0.71	XRF	B-239	19.97	XRF	B-304
Mg				0.41	INAA	B-308	11.9	INAA	B-308
CaO	0.64	Vol.	B-229	54.91	Vol.	B-213	33.28	Vol.	B-266
	0.65	XRF	B-304	55.02	AA	B-228	33.52	ICP	B-197
	0.66	XRF	B-239	55.08	XRF	B-304	33.59	Vol.	B-276
	0.66	ICP	B-309	55.09	XRF	B-210	33.71	XRF	B-239
	0.68	AA	B-228	55.12	Vol.	B-276	33.90	Vol.	B-213
	0.69	XRF	B-210	55.24	Vol.	B-266	34.12	AA	B-228
	0.70	XRF	B-215	55.26	XRF	B-239	34.22	Grav.	B-229
	0.73	ICP	B-226	55.31	Vol.	B-214	34.31	XRF	B-304
	0.73	ICP	B-197	55.50	ICP	B-197	34.40	XRF	B-210
	0.73	AA	B-266	55.68	Grav.	B-229	34.49	Vol.	B-214
				56.26	ICP	B-309	34.65	ICP	B-309
Ca	0.48	INAA	B-308	39.0	INAA	B-308	24.0	INAA	B-308
Na_2O	0.78	XRF	B-304	0.001	FE	B-229	0.006	FE	B-229
	0.96	ICP	B-226	0.002	AA	B-228	0.009	AA	B-228
	1.01	ICP	B-197	0.0024	AA	B-213	0.010	AA	B-213
	1.03	INAA	B-277	0.007	ICP	B-214	0.01348	INAA	B-232
	1.04	FE	B-229	0.008	AA	B-266	0.016	ICP	B-214
	1.05	XRF	B-215	0.05	XRF	B-239	0.02	AA	B-266
	1.05	AA	B-228	0.07	XRF	B-210	0.08	XRF	B-239
	1.06	AA	B-266	<0.01	ICP	B-197	<0.10	ICP	B-197
	1.08	INAA	B-232	0.1	XRF	B-304	0.1	XRF	B-304
	1.10	XRF	B-210				0.14	XRF	B-210
	1.10	XRF	B-239						
	1.10	ICP	B-309						
Na	0.71	INAA	B-308	0.00143	INAA	B-308			

Table A-1 continued

Major	JLk-1			JLs-1			JDo-1		
	%	Method	Code	%	Method	Code	%	Method	Code
	0.82	INAA	B-287						
K_2O	2.70	INAA	B-277	0.0028	AA	B-213	0.0012	AA	B-213
	2.75	XRF	B-239	0.003	AA	B-228	0.002	AA	B-228
	2.77	AA	B-228	0.003	FE	B-229	0.002	XRF	B-304
	2.78	XRF	B-215	0.003	XRF	B-304	0.003	FE	B-229
	2.78	FE	B-229	0.005	FE	B-214	0.003	AA	B-266
	2.85	XRF	B-210	0.008	AA	B-266	0.004	FE	B-214
	2.85	AA	B-266	0.01	XRF	B-239	0.01	XRF	B-239
	2.86	ICP	B-197	0.02	γ cntg.	B-273	0.02	XRF	B-210
	2.86	γ cntg.	B-273	0.03	XRF	B-210	<0.10	ICP	B-197
	2.87	XRF	B-304	<0.10	ICP	B-197			
	2.91	ICP	B-309						
	3.08	ICP	B-226						
K	2.10	INAA	B-308	0.006	INAA	B-308			
	2.42	INAA	B-287						
P_2O_5	0.18	XRF	B-304	0.029	Photom	B-228	0.03	Photom	B-229
	0.20	XRF	B-215	0.030	Photom	B-213	0.03	XRF	B-239
	0.21	ICP	B-197	0.030	Photom	B-214	0.034	Photom	B-214
	0.21	Photom	B-228	0.03	Photom	B-229	0.034	Photom	B-228
	0.21	Photorm	B-229	0.03	XRF	B-239	0.035	Photom	B-213
	0.21	XRF	B-239	0.03	Photom	B-266	0.035	Photom	B-266
	0.21	Photom	B-266	<0.05	ICP	B-197	0.04	XRF	B-304
	0.217	ICP	B-226	0.05	XRF	B-304	<0.05	ICP	B-197
	0.27	ICP	B-309	0.06	ICP	B-309	0.06	ICP	B-309
H_2O^+	5.95	Grav.	B-228	<0.02	Grav.	B-228	<0.02	Grav.	B-228
	6.2	Grav.	B-239	0.12	Grav.	B-229	0.28	Grav.	B-304
	6.30	Grav.	B-304	0.19	Grav.	B-304	0.31	Grav.	B-229
	6.8	Grav.	B-229	<0.2	Grav.	B-239	0.4	Grav.	B-239
H_2O^-	3.30	Grav.	B-304	0.10	Grav.	B-228	0.10	Grav.	B-304
	3.52	Grav.	B-228	0.08	Grav.	B-229	0.13	Grav.	B-228
	3.71	Grav.	B-229	0.09	Grav.	B-239	0.15	Grav.	B-266
	3.87	Grav.	B-266	0.09	Grav.	B-304	0.16	Grav.	B-229
	4.17	Grav.	B-239	0.14	Grav.	B-266	0.16	Grav.	B-239
L.O.I.	9.31	Grav.	B-210	42.61	Grav.	B-309	44.86	Grav.	B-309
	11.36	Grav.	B-309	43.73	Grav.	B-228	46.58	Grav.	B-228
	11.92	Grav.	B-239	43.75	Grav.	B-266	46.71	Grav.	B-213
	12.00	Grav.	B-228	43.78	Grav.	B-210	46.79	Grav.	B-210
	12.18	Grav.	B-266	43.81	Grav.	B-239	46.90	Grav.	B-266
				43.95	Grav.	B-213	47.10	Grav.	B-239
Co_2				42.94	Vol.	B-229	45.65	Vol.	B-229
				43.8	com-IR-abs.	B-239	46.4	com-IR-abs.	B-239
				43.86	Calc.	B-228	46.87	Calc.	B-228
				43.87	Calc.	B-276	46.90	Calc.	B-276
				44.02	Calc.	B-214	47.01	Calc.	B-214
T-C	1.48	com-IR-abs.	B-228	11.98	com-IR-abs.	B-282	12.76	com-IR-abs.	B-282
	1.52	com-IR-abs.	B-282						
Org.-C	1.2	com-IR-abs.	B-239						
Inorg.-C	0.25	com-IR-abs.	B-239						
SO_3	0.06	XRF	B-239	0.03	XRF	B-239	0.02	XRF	B-239
(T-S as SO_3)	0.275	com-IR-abs.	B-228	0.034	Grav.	B-213	0.022	com-IR-abs.	B-282
	0.282	com-IR-abs.	B-282	0.034	com-IR-abs.	B-282	0.028	Grav.	B-213

Table A-1 continued

Minor	JLk-1			JLs-1			JDo-1		
	ppm	Method	Code	ppm	Method	Code	ppm	Method	Code
Ag	0.19	AA	B-266	<0.1	AA	B-266	<0.1	AA	B-266
As	26	INAA	B-308	(0.1)	XRF	B-239	0.112	INAA	B-308
	27	INAA	B-229-2	0.136	INAA	B-308	0.12	INAA	B-229-2
	28	XRF	B-239	0.15	INAA	B-229-2	(0.3)	XRF	B-239
Au	0.0036	AA	B-268	0.00003	AA	B-268	0.00004	AA	B-268
	0.0053	INAA	B-308						
	0.0082	INAA	B-229-2						
Ba	527	ICP	B-226	207	XRF	B-304	6	ICP	B-197
	530	INAA	B-277	445	ICP	B-197	6.0	INAA	B-308
	535	XRF	B-239	510	INAA	B-308	6.7	XRF	B-239
	563	AA	B-266	515	INAA	B-232	25.2	INAA	B-232
	586	ICP	B-197	546.5	AA	B-266	<30	XRF	B-304
	640	INAA	B-308	555	XRF	B-239	56	AA	B-266
	648	INAA	B-232	749	INAA	B-277			
	655	XRF	B-304						
Be	4	AA	B-266	<1	AA	B-266	<1	AA	B-266
Br	8.1	INAA	B-308	0.119	INAA	B-308	0.57	INAA	B-308
	9.3	INAA	B-229-2	0.80	IC	B-238	0.60	INAA	B-229-2
							1.2	IC	B-238
Cd	0.65	AA	B-266	0.15	AA	B-213	0.63	INAA	B-308
				0.159	INAA	B-308	0.64	AA	B-272
				0.16	AA	B-272	0.65	AA	B-213
				0.195	AA	B-266	0.85	AA	B-266
Ce	79	INAA	B-287	0.23	INAA	B-308	<1	XRF	B-239
	82	XRF	B-239	0.69	INAA	B-232	2.2	INAA	B-229-2
	89	XRF	B-304	0.74	INAA	B-229-2	2.3	INAA	B-308
	92	INAA	B-229-2	1.55	INAA	B-287	2.47	INAA	B-232
	93.8	INAA	B-232	1.64	INAA	B-277	3.03	INAA	B-277
	94	INAA	B-308	4.4	XRF	B-239	4.98	INAA	B-287
	95.7	INAA	B-277	48	XRF	B-304	<30	XRF	B-304
Cl	190	XRF	B-239	<5	XRF	B-239	26	IC	B-238
				5.8	IC	B-238	90	XRF	B-239
Co	8	ICP	B-226	0.0103	INAA	B-277	0.114	INAA	B-229-2
	<10	XRF	B-239	0.05	INAA	B-232	0.148	INAA	B-308
	13	XRF	B-304	0.054	INAA	B-229-2	0.166	INAA	B-287
	17	ICP	B-197	0.064	INAA	B-308	0.17	INAA	B-232
	17	AA	B-243	0.0703	INAA	B-287	<5	AA	B-266
	17.8	INAA	B-308	<5	AA	B-266	<10	XRF	B-239
	17.9	INAA	B-232	<10	XRF	B-239			
	18.3	INAA	B-229-2						
	18.5	AA	B-266						
	18.94	INAA	B-277						
	19.1	INAA	B-287						
Cr	61	INAA	B-308	3.1	INAA	B-308	7.2	INAA	B-308
	67	AA	B-266	3.27	INAA	B-277	7.3	INAA	B-229-2
	68.5	INAA	B-277	4.3	INAA	B-229-2	7.49	INAA	B-277
	70	ICP	B-226	4.35	INAA	B-232	<10	XRF	B-239
	70	XRF	B-239	6	AA	B-266	10.2	INAA	B-232
	71	INAA	B-229-2	<10	XRF	B-239	13.5	AA	B-266
	71	AA	B-243						
	74	ICP	B-197						

Table A-1 continued

Minor	JLk-1			JLs-1			JDo-1		
	ppm	Method	Code	ppm	Method	Code	ppm	Method	Code
	93.0	INAA	B-232						
	96	XRF	B-304						
Cs	8.64	INAA	B-277	0.01	INAA	B-232			
	10	AA	B-243	0.021	INAA	B-308			
	11.8	INAA	B-287	0.0253	INAA	B-287			
	12.3	INAA	B-308						
	12.3	INAA	B-232						
Cu	57	ICP	B-226	0.23	AA	B-213	1.3	AA	B-213
	58	XRF	B-239	0.27	AA	B-272	1.3	AA	B-272
	61	ICP	B-197	4.5	AA	B-266	<5	XRF	B-239
	61	AA	B-243	5	XRF	B-239	5.5	AA	B-266
	67.5	AA	B-266						
Dy	5.72	INAA	B-277	0.030	INAA	B-277	0.83	INAA	B-308
	7	XRF	B-239	14	XRF	B-239	0.97	INAA	B-277
	7.3	INAA	B-308				11	XRF	B-239
Er	3.81	INAA	B-277						
Eu	1.26	INAA	B-229-2	0.0051	INAA	B-229-2	0.131	INAA	B-287
	1.28	INAA	B-287	0.0058	INAA	B-308	0.145	INAA	B-229-2
	1.28	INAA	B-308	0.0072	INAA	B-287	0.173	INAA	B-308
	1.32	INAA	B-232	0.01	INAA	B-232	0.18	INAA	B-232
	1.62	INAA	B-277				0.259	INAA	B-277
F	650	XRF	B-239	18	XRF	B-239	214	XRF	B-239
				38	Photom	B-213	250	IC	B-238
				39	IC	B-238	260.	Photom	B-213
Ga	18	INAA	B-287	<1	XRF	B-239	<1	XRF	B-239
	21	INAA	B-308						
	22	XRF	B-239						
Gd	4.9	INAA	B-308	(0.8)	XRF	B-239	1.8	XRF	B-239
	5.4	XRF	B-239						
Hf	3.4	INAA	B-229-2	0.0074	INAA	B-308	0.0169	INAA	B-308
	3.4	XRF	B-239	0.06	INAA	B-232	0.604	INAA	B-277
	3.92	INAA	B-277	0.282	INAA	B-234	1.8	XRF	B-239
	4.10	INAA	B-232	(0.8)	XRF	B-239			
	4.1	INAA	B-287						
	4.9	INAA	B-308						
Hg	0.30	INAA	B-308				0.048	INAA	B-308
Ho	1.52	INAA	B-308				0.164	INAA	B-308
I	25	INAA	B-308						
La	38	XRF	B-239	0.119	INAA	B-308	7	ICP	B-197
	40	INAA	B-308	0.145	INAA	B-277	7.7	INAA	B-308
	40.69	INAA	B-277	0.154	INAA	B-229-2	7.8	INAA	B-229-2
	41.7	INAA	B-287	2.5	XRF	B-239	8.20	INAA	B-277
	42	ICP	B-197				8.3	XRF	B-239
	42.2	INAA	B-232				8.52	INAA	B-232
	47	INAA	B-229-2						
Li	48	AA	B-243	<1	AA	B-266	<1	AA	B-266
	50.5	AA	B-266						
Lu	0.52	INAA	B-287	0.03	INAA	B-232	0.044	INAA	B-277
	0.58	INAA	B-277	0.031	INAA	B-277	0.045	INAA	B-308
	0.65	INAA	B-308				0.06	INAA	B-232
	0.66	INAA	B-232						

Table A-1 continued

Minor	JLk-1			JLs-1			JDo-1		
	ppm	Method	Code	ppm	Method	Code	ppm	Method	Code
Mo	2.05	AA	B-266	<0.2	AA	B-266	0.59	AA	B-266
Nb	15	XRF	B-304	<1	XRF	B-239	<1	XRF	B-239
	16	XRF	B-239	<4	XRF	B-304	<4	XRF	B-304
Nd	35	XRF	B-239	0.133	INAA	B-308	4.8	INAA	B-308
	35.6	INAA	B-232	<1	XRF	B-239	5	XRF	B-239
	39	INAA	B-308	1.74	INAA	B-232	5.05	INAA	B-232
							5.99	INAA	B-277
Ni	30	XRF	B-239	0.30	AA	B-213	3.0	AA	B-213
	32	ICP	B-226	0.36	AA	B-272	3.0	AA	B-272
	33	AA	B-243	0.47	INAA	B-308	3.5	INAA	B-308
	33	AA	B-266	<10	XRF	B-239	<10	XRF	B-239
	35	ICP	B-197	<10	AA	B-266	<10	AA	B-266
	40	XRF	B-304						
	41	INAA	B-308						
Pb	38	ICP	B-197	2.4	XRF	B-239	2.1	XRF	B-239
	39	ICP	B-226	<6	XRF	B-304	<6	XRF	B-304
				<10	AA	B-266	<10	AA	B-266
	39.5	AA	B-266						
	43	XRF	B-304						
	45	XRF	B-239						
	50	AA	B-243						
Pr	7.30	INAA	B-277	<1	XRF	B-239	1.17	INAA	B-308
	8.4	INAA	B-308				2.8	XRF	B-239
	9.5	XRF	B-239						
Rb	121	AA	B-243	0.163	INAA	B-308	2.0	XRF	B-239
	145	AA	B-266	2.9	XRF	B-239	5	XRF	B-304
	147	XRF	B-239	7	XRF	B-304	<10	AA	B-266
	147	XRF	B-304	<10	AA	B-266			
	150	INAA	B-308						
	165	INAA	B-277						
S	230	XRF	B-239	110	XRF	B-239	80	XRF	B-239
(T-S)	1100	com-IR-abs.	B-228	135	com-IR-abs.	B-282	86	com-IR-abs.	B-282
	1130	com-IR-abs.	B-282	136	Grav.	B-213	112	Grav.	B-213
Sb	2.1	INAA	B-229-2	0.0162	INAA	B-308	0.035	INAA	B-229-2
	2.1	INAA	B-308	0.017	INAA	B-229-2	0.036	INAA	B-308
Sc	13	XRF	B-239	0.0292	INAA	B-287	0.123	INAA	B-229-2
	15.2	INAA	B-229-2	0.03	INAA	B-232	0.134	INAA	B-277
	15.7	INAA	B-287	0.031	INAA	B-229-2	0.138	INAA	B-308
	15.9	INAA	B-308	0.031	INAA	B-308	0.149	INAA	B-287
	16	ICP	B-197	0.032	INAA	B-277	0.15	INAA	B-232
	16.12	INAA	B-277	37	XRF	B-239	21	XRF	B-239
	16.2	INAA	B-232						
Se	0.455	Fluo.	B-242	0.0568	Fluo.	B-242	0.0327	Fluo.	B-242
	0.85	INAA	B-308				0.050	INAA	B-308
Sm	7.2	XRF	B-239	0.026	INAA	B-308	0.807	INAA	B-277
	7.5	INAA	B-287	0.182	INAA	B-277	0.83	INAA	B-308
	8.14	INAA	B-277	0.185	INAA	B-229-2	0.89	INAA	B-229-2
	8.3	INAA	B-308	0.19	INAA	B-232	0.95	INAA	B-232
	8.35	INAA	B-232	3.4	XRF	B-239	2.8	XRF	B-239
	9.5	INAA	B-229-2						
Sr	58	ICP	B-226	188	INAA	B-287	85	INAA	B-287

Table A-1 continued

Minor	JLk-1			JLs-1			JDo-1		
	ppm	Method	Code	ppm	Method	Code	ppm	Method	Code
	59	AA	B-266	265	XRF	B-304	114	XRF	B-304
	68	XRF	B-304	287	ICP	B-197	115	ICP	B-197
	69	ICP	B-197	296	AA	B-213	118	AA	B-213
	70	INAA	B-308	300	XRF	B-239	119	INAA	B-232
	71	XRF	B-239	309	INAA	B-232	120	XRF	B-239
	74	AA	B-243	317	AA	B-266	126	AA	B-266
	105	INAA	B-232	320	INAA	B-308	134	INAA	B-308
Ta	1.16	INAA	B-287						
	1.23	INAA	B-229-2						
	1.29	INAA	B-232						
	1.29	INAA	B-308						
	2.05	INAA	B-277						
Tb	1.20	INAA	B-277	0.0038	INAA	B-308	0.092	INAA	B-277
	1.31	INAA	B-308	0.0045	INAA	B-287	0.138	INAA	B-308
	1.39	INAA	B-232				0.15	INAA	B-232
							0.159	INAA	B-287
Th	18.0	INAA	B-287	0.020	INAA	B-308	0.032	INAA	B-229-2
	18.5	INAA	B-308	0.023	INAA	B-229-2	0.045	INAA	B-308
	19.10	γ cntg.	B-273	0.03	INAA	B-232	0.05	INAA	B-232
	20	INAA	B-229-2	0.043	INAA	B-287	0.104	INAA	B-287
	20	XRF	B-239	1.9	XRF	B-239	(0.4)	XRF	B-239
	20	XRF	B-304	<6	XRF	B-304	6	XRF	B-304
	20.42	INAA	B-277						
	21.0	INAA	B-232						
Tl	1.07	AA	B-266	<0.2	AA	B-266	<0.2	AA	B-266
	1.7	Fluo.	B-284	<0.05	Fluo.	B-284	<0.05	Fluo.	B-284
Tm	0.66	INAA	B-308				0.058	INAA	B-308
U	2.66	INAA	B-277	1.41	INAA	B-277	0.67	INAA	B-277
	3.3	INAA	B-308	1.54	INAA	B-308	0.73	INAA	B-308
	3.6	XRF	B-239	1.8	INAA	B-229-2	0.84	INAA	B-229-2
	3.90	γ cntg.	B-273	1.85	γ cntg.	B-273	1.00	INAA	B-232
	4.30	INAA	B-232	2.09	INAA	B-232	1.0	XRF	B-239
	4.4	INAA	B-229-2	2.1	XRF	B-239	1.04	γ cntg.	B-273
V	103	XRF	B-239	2.7	XRF	B-239	2.3	XRF	B-239
	104	AA	B-266	3.1	INAA	B-308	3.2	INAA	B-308
	111	ICP	B-226	<10	AA	B-266	<10	AA	B-266
	114	INAA	B-308						
	120	ICP	B-197						
	126	AA	B-243						
	153	XRF	B-304						
W	2.7	INAA	B-308	0.21	INAA	B-308	0.26	INAA	B-308
Y	39	ICP	B-197	(0.1)	XRF	B-239	11	XRF	B-239
	43	XRF	B-304	<6	XRF	B-304	14	XRF	B-304
	44	XRF	B-239						
Yb	3.95	INAA	B-232	0.0161	INAA	B-308	0.326	INAA	B-287
	4.08	INAA	B-277	0.021	INAA	B-287	0.34	INAA	B-308
	4.4	INAA	B-308	1.8	XRF	B-239	0.432	INAA	B-277
	4.6	XRF	B-239				0.58	INAA	B-232
							2.4	XRF	B-239
Zn	105	INAA	B-287	2.02	INAA	B-287	23.5	INAA	B-287
	143.5	AA	B-266	2.8	AA	B-272	34	AA	B-213

Table A-1 continued

Minor	JLk-1			JLs-1			JDo-1		
	ppm	Method	Code	ppm	Method	Code	ppm	Method	Code
	145	ICP	B-226	2.92	INAA	B-232	34	ICP	B-197
	148	XRF	B-239	3.2	AA	B-213	34.6	INAA	B-232
	155	ICP	B-197	4.1	INAA	B-308	36	INAA	B-308
	156	INAA	B-308	7.5	AA	B-266	36	XRF	B-304
	160	AA	B-243	9.5	XRF	B-239	38	XRF	B-239
	172	XRF	B-304				39.5	AA	B-266
	178	INAA	B-232						
Zr	94	AA	B-243	<1	XRF	B-239	9.33	INAA	B-232
	131	XRF	B-304	12.0	INAA	B-287	11.0	INAA	B-287
	147	INAA	B-232	14.5	INAA	B-232	<1	XRF	B-239
	153	XRF	B-239						
	178	INAA	B-308						

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