Chemical Studies on the Ocean-LXV.

Chemical Studies of the Shallow-water Deposits-18.

On the Chemical Constituents of the Shallow-water Deposits along the Sea-coasts of Osaka, Kyoto and Fukui Prefectures, and the Generalized Consideration of the Shallow-water Deposits in Japan Proper*

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Abstract: In this paper, the results of analysis, carried out laying emphasis on K, of 10 kinds of the deposits collected from the sea-coasts of Ōsaka, Kyōto and Fukui Prefectures, are described, and further, the generalized considerations of all the samples from all the sea-coasts of Japan Proper are presented. From the summarized results of all samples, it is found that the K_2O content is exceedingly high in those from Hiroshima, Yamaguchi and Shimane Prefectures, especially so in the deposits from Hiroshima, while it is exceedingly low in many of the deposits from Aomori, Miyagi, Chiba, Kanagawa, Wakayama, Mie, Fukui Prefectures and the like, especially so in those collected at Sagami Bay.

1. Introduction

In the previous paper (UEDA, 1956 a), the author has reported on the chemical composition of 9 kinds of the deposits from the sea-coasts of Miyagi, Fukushima and Ibaraki Prefectures. In this paper, the analytical results of 10 kinds of deposits from the sea-coasts of Ōsaka, Kyōto and Fukui Prefectures are described, and further, summarizing these results and all other results already reported (ISHIBASHI and UEDA, 1956 a, b, c, d, e, f, g; ISHIBASHI, UEDA and YAMAMOTO 1956; UEDA, 1956 a, b, c), the generalized considerations concerning all the samples (110 kinds) from all the sea-coasts of Japan Proper are presented.

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2. Samples

Locality and date of sampling are shown in Table 1.

Table 1. Locality and date of sampling.

Sample No.	Locality	Date
101	Yoshimi, Tajirimura, Sennangun, Ōsakafu	Aug. 25, 1947
110	Kamiyamachi, Kishiwadashi, Ōsakafu	Aug. 15, 1948
102	Shiomimachi, Izumiōtsushi, Ōsakafu	Aug. 26, 1947
103	Hamazumemura, Takenogun, Kyōtofu	Aug. 18, 1947
104	Iwagahana, Yōrōmura, Yozagun, Kyōtofu	Sept. 15, 1948
109	Shimasaki, Miyazumachi, Yozagun, Kyōtofu	Aug. 2, 1947
105	Higashikanzaki, Kanzakimura, Kasagun, Kyōtofu	Aug. 24, 1948
106	Wakamiya, Takahamamachi, Ōigun, Fukuiken	Aug. 1, 1947
107	Shirahige, Obamamachi, Onyūgun, Fukuiken	Sept. 30, 1947
108	Ishishinbo, Natsumemura, Sakaigun, Fukuiken	Sept. 25, 1947

All of these samples are the deposits collected in the neighbourhood of the shoreline.

Sample 101: yellowish brown sand; collected by K. SAKAI at the point about 700 m northeast of the estuary of the Kashii River.

Sample 110: yellowish brown sand containing many gravels; collected by E. TAKAO at the point about 1 km northeast of the estuary of the Tsuda River.

Sample 102: light yellowish brown sand; collected by N. MORITA at the point about 500 m northeast of the estuary of the Ōtsu River.

Sample 103: light brown sand containing shell fragments; collected by K. KANAMASU at the point about 700 m northeast of the estuary of the Kizu River.

Sample 104: light brown sand; collected by M. NODA at the point about 400 m northeast of the estuary of the Sai River.

Sample 109: yellowish brown sand; collected by K. ŌTSUKA at the point about 100 m northwest of the estuary of the Ōte River.

Sample 105: light brownish gray sand; collected by Y. TSUJI at the point about 1 km southeast of the estuary of the Yura River.

Sample 106: greenish black sand containing shell fragments and many small gravels; collected by S. MORITSUGU at the point about 2.8 km southeast of the estuary of the Sekiya River.

Sample 107: grayish brown sand; collected by Y. MIZUE at the point about 1.3 km southwest of the estuary of the Minami River.

Sample 108: brown sand; collected by S. FUJITA at the sea-coast of Ishishinbo.

The size composition of these samples is shown in Table 2.

The geology of the land adjacent to the locations sampled is briefly as follows*:

In Ōsaka districts, granites distribute only at the eastern and southern margins, and most parts are composed of Quaternary formations.

* The parentheses are for the rocks and formations which distribute in the land areas not so far from the location of collection.

Table 2. Size composition of the deposits.

Mesh ^(a)	> 8	14	28	48	100	200	pan
Sample No.	%	%	%	%	%	%	%
101	6	13	76	5	0	0	0
110	56	16	25	2	0	1	0
102	5	3	17	45	29	1	0
103	0	0	1	30	69	1	0
104	14	6	38	27	12	3	0
109	5	31	34	19	9	2	0
105	0	0	7	58	33	2	0
106	67	26	7	0	0	0	0
107	10	30	37	19	4	0	0
108	0	2	77	20	1	0	0

(a) Tyler standard.

Sample 101: Quaternary formations. The Kashii River which pours into the sea near the location, runs mainly through the Mesozoic formations, quartz-porphyry and granite-porphyry.

Samples 110 and 102: Quaternary formations. The Tsuda and Ōtsu Rivers which pour near the locations, run mainly through granites.

As for Kyōto and Fukui Prefectures, Paleozoic formations distribute widely in the districts surrounding Wakasa Bay, and granites develop in Yoza Peninsula and in the neighbourhood of Tsuruga.

Sample 103: Tertiary formations; (Quaternary formations).

Sample 104: Tertiary formations; (andesite).

Sample 109: Quaternary formations; (granites).

Sample 105: Paleozoic formations. The Yura River which pours into the sea near the location, runs mainly through Paleozoic formations, diorite and Mesozoic formations.

Sample 106: diorite.

Sample 107: Paleozoic formations and Quaternary formations.

Sample 108: Quaternary formations; (andesite and Tertiary formations).

3. Experimental Procedure, Results and Discussion

Experiments were carried out as described previously (ISHIBASHI and UEDA, 1956 a).

The analytical results of the air-dried samples are shown in Table 3. From this table we obtained the percentages of chemical constituents in the sea-salt-free samples dried

at 105~110°C as shown in Table 4*.

As obvious from Table 4, all deposits from Ōsaka Bay, that is, Samples 101, 110 and 102, and some of the deposits from Wakasa Bay,

Table 3. Chemical composition of the deposits.

Sample No.	101	110	102	103	104	109	105	106	107	108
	%	%	%	%	%	%	%	%	%	%
Drying loss	0.55	0.38	0.58	0.89	0.75	0.40	0.67	0.46	0.32	0.56
Ignition loss	1.15	1.28	1.11	5.19	1.00	0.89	1.64	5.62	1.32	1.69
Fe ₂ O ₃	1.43	0.96	0.98	1.93	1.64	1.22	2.52	7.20	2.50	3.16
TiO ₂	0.10	0.14	0.08	0.18	0.11	0.07	0.17	0.93	0.24	0.30
Al ₂ O ₃	6.69	8.98	6.87	9.47	11.68	10.19	6.11	11.90	5.06	12.57
MnO	0.01	0.01	0.01	0.02	0.02	0.01	0.03	0.10	0.01	0.01
CaO	0.47	1.43	0.82	5.51	1.09	1.33	0.87	8.57	0.62	1.56
MgO	0.40	1.37	0.70	1.27	0.62	1.02	0.88	3.32	0.80	1.24
K ₂ O	1.92	1.28	1.92	2.19	3.16	3.17	0.61	0.77	0.48	2.09
Na ₂ O	1.15	1.50	1.34	2.02	3.20	2.00	0.86	2.88	0.76	2.09
SiO ₂	86.21	82.65	85.43	71.35	76.58	80.10	85.33	57.79	87.73	73.80
SO ₃	0.05	0.10	0.10	0.15	0.03	0.11	0.07	0.09	0.05	0.08
Cl	0.15	0.05	0.18	0.43	0.02	0.16	0.01	0.07	0.04	0.07
P ₂ O ₅	trace	0.05	0.04	0.07	0.03	0.03	0.04	0.15	0.05	0.12
CO ₂	—	—	—	3.05	—	—	—	2.97	—	—
N	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.

Table 4. Chemical composition of the deposits on sea-salt-free and dry basis (calculated from Table 3).

Sample No.	101	110	102	103	104	109	105	106	107	108
	%	%	%	%	%	%	%	%	%	%
Fe ₂ O ₃	1.44	0.96	0.99	1.96	1.65	1.23	2.54	7.24	2.51	3.18
TiO ₂	0.10	0.14	0.08	0.18	0.11	0.07	0.17	0.94	0.24	0.30
Al ₂ O ₃	6.75	9.02	6.93	9.63	11.77	10.26	6.15	11.97	5.08	12.66
MnO	0.01	0.01	0.01	0.02	0.02	0.01	0.03	0.10	0.01	0.01
CaO	0.47	1.44	0.82	5.59	1.10	1.34	0.88	8.62	0.62	1.57
MgO	0.38	1.37	0.69	1.24	0.62	1.01	0.89	3.33	0.80	1.24
K ₂ O	1.94	1.29	1.94	2.22	3.19	3.19	0.61	0.77	0.48	2.10
Na ₂ O	1.05	1.47	1.22	1.73	3.22	1.89	0.86	2.85	0.73	2.05
SiO ₂	86.92	83.04	86.21	72.56	77.19	80.66	85.92	58.13	88.07	74.31
SO ₃	0.03	0.09	0.08	0.10	0.03	0.09	0.07	0.08	0.05	0.07
P ₂ O ₅	trace	0.05	0.04	0.07	0.03	0.03	0.04	0.15	0.05	0.12
CO ₂	—	—	—	3.10	—	—	—	2.99	—	—
N	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.	n. d.
Na ₂ O+K ₂ O	2.99	2.76	3.16	3.95	6.41	5.08	1.47	3.62	1.21	4.15
K ₂ O/Na ₂ O	1.85	0.88	1.59	1.28	0.99	1.69	0.71	0.27	0.66	1.02

* We performed this calculation on the basis of the same assumption as in the previous paper (ISHI-BASHI and UEDA, 1955 a).

such as Samples 109, 105 and 107, are exceedingly high in SiO_2 and low on the whole in Fe_2O_3 , TiO_2 , Al_2O_3 , MnO , CaO , MgO , etc. Among these deposits, it is remarkable that Sample 101 is high in SiO_2 and low in Al_2O_3 , CaO and MgO ; Sample 110, low in Fe_2O_3 ; Sample 102, high in SiO_2 and low in Fe_2O_3 and Al_2O_3 ; Samples 105 and 107, high in SiO_2 and low in Al_2O_3 and alkalis. On the other hand, Sample 106 is entirely different from the other sands in this report and similar to the blackish sands from Sagami Bay (UEDA, 1956 c) both in its appearance and chemical composition. Namely, it is exceedingly low in SiO_2 and K_2O , and considerably high in Fe_2O_3 , TiO_2 , CaO , MgO , etc.

As for alkalis, the K_2O content ranges 0.48~3.19%, being considerably high in Samples 104 and 109, and exceedingly low in Samples 105, 106 and 107. The Na_2O content is high in Samples 104 and 106, but low in most of the others. In consequence, there are comparatively many samples in which the $\text{Na}_2\text{O}+\text{K}_2\text{O}$ content is low.

Generalized Consideration on the Analytical Results of all the Samples from all the Sea-coasts of Japan Proper

Now, as we have analysed 110 kinds of deposits, i.e. 30 kinds of muds* and 80 kinds of sands, which are all samples collected at all the sea-coasts of Japan Proper, we have summarized the analytical results, as shown in Table 5, in which the average chemical composition of all samples and the maximum, minimum and average values of each chemical constituents of all muds and sands are described, respectively. The average chemical composition of the shallow-water deposits of Korea, red clays and rocks is also recited for comparison in this table.

Based on the data in Table 5 and the analytical results of all samples so far reported, the author has discussed the distribution of the main constituents in these deposits, comparing their average values with those of the shallow-water deposits of Korea, red clays, igneous rocks, shales and sandstones.

1. SiO_2 : The maximum SiO_2 content in

* Sandy muds are also included.

muds is 83.82% of Sample 75 collected at Nishitonda, Wakayama Prefecture, and the minimum is 53.19% of Sample 22 at Takahama, Aichi Prefecture; the maximum in sands is 89.62% of Sample 70 at Akashi, Hyōgo Prefecture, and the minimum is 31.24% of Sample 37 at Funagawaminato, Akita Prefecture. As for the muds, they were collected mostly at Aichi, Okayama and Hiroshima Prefectures, of which the muds of Aichi are relatively sandy and so many of them are rich in SiO_2 , having above 70% SiO_2 , while those of Okayama and Hiroshima Prefectures are generally low in it. Of the muds from other districts, those of Wakayama Prefecture are exceedingly high in SiO_2 . As for the SiO_2 content in sands, it is mostly above 70%, being especially high in many of the deposits from those prefectures as Hiroshima, Yamaguchi, Kyōto, Mie, Wakayama, Ōsaka, etc., while low in relatively small numbers of sands, being about 60% or less, in those from Aomori, Iwate, Kanagawa, Shizuoka, Tottori, etc. The average SiO_2 content in muds amounts to 66.49%, which is similar to that in shallow-muds from Korea, and higher than in red clays, igneous rocks and shales, but lower than in sandstones. The average SiO_2 content in sands amounts to 73.20%, which is almost the same as that in sands from Korea, and higher than in red clays, igneous rocks and shales, but lower than in sandstones.

2. Fe_2O_3 : The maximum Fe_2O_3 content in muds is 7.29% of Sample 52 collected at Kojima Bay, and the minimum is 1.79% of Sample 76 at Shinjō, Wakayama Prefecture; the maximum in sands is 13.00% of Sample 43 at Rokukasho, Aomori Prefecture, and the minimum is 0.46% of Sample 63 at Nago, Yamaguchi Prefecture. As for the Fe_2O_3 content in muds, it ranges 3~6% in most of the deposits, though it amounts to about 7% in several deposits from Miyagi, Aichi and Okayama Prefectures, and is less than 2% in the muds from Wakayama Prefecture. As for the sands, the Fe_2O_3 content is exceedingly high, amounting to about 10%, in some of the deposits from Aomori, Iwate, Kanagawa and Shizuoka Prefectures, and

Table 5. Summary of the results obtained*.

	Average of all Japanese samples (110 kinds)	Japanese muds (30 kinds)			Japanese sands (80 kinds)			Korean muds ^c	Korean sands ^d	Red clays ^e	Red clays ^f	Igneous rocks ^g	Shales ^h	Sand-stones ^g
		Maxi-mum	Mini-mum	Average	Maxi-mum	Mini-mum	Average							
Fe ₂ O ₃	3.73%	7.29%	1.79%	4.42%	13.00%	0.46%	3.48%	7.16%	3.08%	8.93%	11.84%	7.30%	6.74%	1.40%
TiO ₂	0.40	0.91	0.15	0.49	1.40	0.07	0.36	—	—	0.91	—	1.05	0.65	0.25
Al ₂ O ₃	11.96	19.28	7.63	14.26	18.84	4.72	11.10	15.14	12.68	17.35	22.70	15.34	15.40	4.77
MnO	0.06	0.32	trace	0.06	0.47	trace	0.06	0.06	0.04	0.99	1.78	0.124	—	—
CaO	3.45	7.46	0.82	2.32	29.76	0.45	3.87	2.37	3.19	2.64	1.85	5.08	3.11	5.50
MgO	1.44	3.05	0.25	1.33	9.97	0.15	1.47	1.56	1.25	3.62	2.69	3.49	2.44	1.16
K ₂ O	1.98	3.25	1.18	2.15	5.05	0.07	1.91	2.31	2.39	2.78	2.96	3.13	3.24	1.31
Na ₂ O	2.00	3.44	0.40	1.66	3.93	0.73	2.13	2.27	2.64	5.38	1.54	3.84	1.30	0.45
SiO ₂	71.37	83.82	53.19	66.49	89.62	31.24	73.20	64.40	72.82	56.70	54.15	59.14	58.10	78.33
SO ₃	0.35	2.73	0.05	0.97	1.10	—	0.12	0.40	0.17	—	0.20	0.13	0.64	0.07
P ₂ O ₅	0.08	0.20	0.04	0.11	0.24	trace	0.07	0.11	0.07	0.48	0.30	0.299	0.17	0.08
CO ₂	1.07	5.02	—	0.79	23.81	—	1.17	0.39	0.71	—	—	0.101	2.63	5.03
N	0.09*	0.27	0.05	0.12	0.04	—	0.02 ^b	0.10	0.02	—	—	—	—	—
Na ₂ O+K ₂ O	3.98	6.61	2.31	3.81	7.57	1.21	4.04	4.58	5.03	8.16	4.50	6.97	4.54	1.76
K ₂ O/Na ₂ O**	0.99	4.78	0.58	1.30	3.64	0.05	0.90	1.02	0.91	0.52	1.92	0.82	2.49	2.91
Drying loss***	1.68	11.10	0.88	4.27	4.57	0.02	0.71	3.46	1.02	—	—	—	—	—
Ignition loss***	3.86	12.90	1.87	6.96	25.26	0.42	2.70	4.69	1.74	—	—	—	—	—

* The chemical composition of sea-deposits is shown on the sea-salt-free and dry basis, but as for that of rocks, it is cited for comparison from the original as it is.

** For the convenience of comparison, particularly in this table, average value of K₂O/Na₂O was calculated from average K₂O and average Na₂O.

*** The results are expressed on the air-dry basis.

(a) Average of 39 kinds of samples. (b) Average of 9 kinds of samples. (c) Average chemical composition of 20 kinds of Korean muds (ISHIBASHI and UEDA, 1955 b). (d) Average chemical composition of 11 kinds of Korean sands (ISHIBASHI and UEDA, 1955 b).

(e) Average chemical composition of 16 kinds of red clays by HAMAGUCHI (HAMAGUCHI, 1942). (f) Average chemical composition of 6 kinds of red clays by ISHIBASHI and HARADA (ISHIBASHI and HARADA, 1938). (g) Average chemical composition of igneous rocks, shales and sandstones (CLARKE, 1924).

exceedingly low, being about 1%, in many of the deposits from Hiroshima, Yamaguchi, Ōsaka, etc. The average Fe_2O_3 content in muds amounts to 4.42%, which is lower than in Korean muds, red clays, igneous rocks and shales, but higher than in sandstones. The average in sands amounts to 3.48%, which is similar to that in Korean sands and lower than in red clays, igneous rocks and shales, but higher than in sandstones.

3. TiO_2 : The maximum TiO_2 content in muds is 0.91% of Sample 52 collected at Kojima Bay, and the minimum is 0.15% of Sample 21 at Terazu, Aichi Prefecture; the maximum in sands is 1.40% of Sample 40 at Ushirogata, Aomori Prefecture, and the minimum is 0.07% of Samples 79 and 109 which were collected at Ōyodo, Mie Prefecture and Miyazu, Kyōto Prefecture, respectively. As to the relation between the TiO_2 content and those of the other constituents is not so clear, but there is a tendency in some degree that TiO_2 is generally high in the deposits having low SiO_2 and high Fe_2O_3 , and it is low in those having high SiO_2 and low Fe_2O_3 . The average TiO_2 contents in muds and sands are 0.49% and 0.36%, respectively, which are lower than in red clays, igneous rocks and shales, but higher than in sandstones.

4. Al_2O_3 : The maximum Al_2O_3 content in muds is 19.28% of Sample 51 collected at Kojima Bay, and the minimum is 7.63% of Sample 23 at Handa, Aichi Prefecture; the maximum in sands is 18.84% of Sample 89 at Usami, Shizuoka Prefecture, and the minimum is 4.72% of Sample 70 at Akashi, Hyōgo Prefecture. The Al_2O_3 content is generally high in muds which are clayey, and considerably low in sandy muds which were collected at Aichi and Wakayama Prefectures. As for the Al_2O_3 content in sands, it is considerably lower than in muds, and only in several sands it is above 15%, most of them having about 13% or lower. And it is generally high in the sands with low content of SiO_2 collected from Tottori, Miyagi, Kanagawa, Shizuoka Prefectures, etc., while it is low in those with high content of SiO_2

obtained from Hiroshima, Yamaguchi, Kyōto, Mie, Wakayama, Ōsaka, etc. Though there are some exceptions, the Fe_2O_3 and Al_2O_3 contents are in general high in the deposits of low SiO_2 content and low in those of high SiO_2 content. The average Al_2O_3 content in muds amounts to 14.26%, which is similar to that in Korean muds, igneous rocks and shales, and lower than in red clays, but higher than in sandstones. The average in sands amounts to 11.10%, which is slightly lower than in Korean sands, and lower than in red clays, igneous rocks and shales, but higher than in sandstones.

5. MnO : The maximum MnO content in muds is 0.32% of Sample 51 collected at Kojima Bay, and the minimum is found in the trace of Sample 75 at Nishitonda, Wakayama Prefecture; the maximum in sands is 0.47% of Sample 43 at Rokukasho, Aomori Prefecture, and the minimum is in the trace of Sample 59 at Nakanoseki, Yamaguchi Prefecture. The MnO content in the shallow-water deposits is exceedingly low on the whole, most of them having less than 0.1% and it is found nearly as trace in many samples. The deposits whose MnO content amounts to 0.1% or more, are only 14% of the total samples, which are mostly the deposits with high content of Fe_2O_3 collected from Aomori, Iwate, Kanagawa, Shizuoka, Okayama Prefectures, etc. The average MnO content both in muds and in sands is 0.06%, which is similar to that in Korean deposits, and lower than in red clays and igneous rocks, especially lower than in red clays. Thus shallow-water deposits are remarkably different from deep-sea deposits in the MnO content.

6. CaO and MgO : The maximum content of CaO in muds is 7.46% of Sample 80 collected at Funakoshi, Mie Prefecture and that of MgO is 3.05% of Sample 55 at Yorishima, Okayama prefecture; the minimum contents of CaO and MgO are, respectively, 0.82% of Sample 75 at Nishitonda, Wakayama Prefecture and 0.25% of Sample 20 at Oitsu, Aichi Prefecture; the maximum contents of CaO and MgO in sands are 29.76% of Sample 63 at Nago, Yamaguchi Prefecture and 9.97%

of Sample 43 at Rokukasho, Aomori Prefecture, respectively; the minimum contents of CaO and MgO are 0.45% of Sample 29 at Saizaki, Hiroshima Prefecture and 0.15% of Sample 70 at Akashi, Hyōgo Prefecture, respectively. As for the CaO content, it is high in the deposits which are rich in carbonates. So, if we recalculate the CaO % based on the CaCO_3 -free samples, assuming that the shell fragments consist of CaCO_3 alone, and CO_2 in the analyses results from shell fragments only, it is mostly high in the sands with relatively low content of SiO_2 which were collected at Aomori, Iwate, Kanagawa, Shizuoka, Tottori Prefectures, etc., and is low on the whole in those with high content of SiO_2 , such as the muds from Aichi and Wakayama and the sands from Hiroshima, Yamaguchi, Mie, Ōsaka, Kyōto, etc. And the MgO content is also generally high in those with low content of SiO_2 and low in those with high content of SiO_2 . The average CaO and MgO contents in muds amount to 2.32% and 1.33%, respectively, and those in sands amount to 3.87% and 1.47%, respectively. The CaO in muds is lower than in igneous rocks, shales and sandstones, and similar in Korean muds and red clays. The CaO in sands is higher than in Korean sands, red clays and shales, but lower than in igneous rocks and sandstones. The MgO in muds and sands is lower than in red clays, igneous rocks and shales, and similar in Korean deposits and sandstones. The average content of CaO is lower than that of MgO in red clays, while as for shallow-water deposits the former is similar to* or higher** than the latter even on the CaCO_3 -free basis.

7. P_2O_5 : The maximum P_2O_5 content in muds is 0.20% of Samples 19 and 25 which were collected at Tahara and Shimonoishiki, Aichi Prefecture, respectively, the minimum being 0.04% of Sample 76 at Shinjō, Wakayama Prefecture; the maximum in sands is 0.24% of Sample 43 at Rokukasho, Aomori Prefecture, and the minimum is found in the traces of Samples 29, 79 and 101 which were collected at Saizaki, Hiroshima;

* in the muds. ** in the sands.

Ōyodo, Mie; Tajiri, Ōsaka Prefecture, respectively. The average P_2O_5 content in muds is 0.11% and that in sands is 0.07%, both of which are the same as in Korean muds and sands, respectively, and lower than in red clays, igneous rocks and shales, but similar in sandstones.

8. K_2O and Na_2O :

K_2O : The maximum K_2O content in muds is 3.25% of Sample 26 collected at Shingai, Hiroshima Prefecture, and the minimum is 1.18% of Sample 75 at Nishitonda, Wakayama Prefecture; the maximum in sands is 5.05% of Sample 30 at Tadanoumi, Hiroshima Prefecture, the minimum being 0.07% of Sample 89 at Usami, Shizuoka Prefecture. As for the K_2O content in muds, it is higher in the deposits from Hiroshima Prefecture, being about 2~3% in all the deposits, while in the deposits from Aichi, Okayama and most of other prefectures, there are samples in which it is less than 2%. As for the K_2O content in sands, it is highest in those from Hiroshima Prefecture, being above 3% in all the samples, amounting to about 4~5% in some of them, and higher in those from Yamaguchi and Shimane Prefectures, being above 3% in many of them, and is relatively high in those from Ishikawa, Toyama, Niigata, Yamagata, Hyōgo, Tottori, Kyōto Prefectures, etc., being about 2~3% in many of them. On the other hand, it is remarkably low in many of the sands from Aomori, Miyagi, Chiba, Kanagawa, Wakayama, Mie, Fukui, etc., being only 1% or less. The average K_2O content in muds amounts to 2.15%, which is similar to that in Korean muds, and lower than in red clays, igneous rocks and shales, but higher than in sandstones. The average in sands amounts to 1.91%, which is lower than in Korean sands, red clays, igneous rocks and shales, but higher than in sandstones.

Na_2O : The maximum Na_2O content in muds is 3.44% of Sample 32 collected at Shimono, Hiroshima Prefecture, and the minimum is 0.40% of Sample 19 at Tahara, Aichi Prefecture; the maximum in sands is 3.93% of Sample 68 at Yodoe, Tottori

Prefecture, the minimum being 0.73% of Sample 107 at Obama, Fukui Prefecture. The average Na_2O content in muds amounts to 1.66%, which is similar to that in red clays by ISHIBASHI and HARADA and shales, and lower than in Korean muds, red clays by HAMAGUCHI and igneous rocks, but higher than in sandstones. The average in sands amounts to 2.13%, which is lower than in Korean sands, red clays by HAMAGUCHI and igneous rocks, but higher than in red clays by ISHIBASHI and HARADA, shales and sandstones. Especially the Na_2O content is lower in shallow-water deposits than in red clays by HAMAGUCHI.

$\text{Na}_2\text{O}+\text{K}_2\text{O}$: The maximum $\text{Na}_2\text{O}+\text{K}_2\text{O}$ content in muds is 6.61% of Sample 32 collected at Shimono, Hiroshima Prefecture, and the minimum is 2.31% of Sample 19 at Tahara, Aichi Prefecture; the maximum in sands is 7.57% of Sample 30 at Tadanoumi, Hiroshima Prefecture, and the minimum is 1.21% of Sample 107 at Obama, Fukui Prefecture. The $\text{Na}_2\text{O}+\text{K}_2\text{O}$ content is relatively high in the deposits from Hiroshima, Shimane, Tottori, Ishikawa, Toyama, Niigata, Yamagata and Ibaraki Prefectures, being above 4% in all the samples, while in those from Aomori, Miyagi, Chiba, Kanagawa, Mie, Osaka, Okayama, etc., it is generally low, being less than 3% in many of them. The average $\text{Na}_2\text{O}+\text{K}_2\text{O}$ content in muds is 3.81% and that in sands is 4.04%, which are slightly lower than in Korean deposits, red clays by ISHIBASHI and HARADA and shales, and lower than in red clays by HAMAGUCHI and igneous rocks, but higher than in sandstones.

$\text{K}_2\text{O}/\text{Na}_2\text{O}$: The maximum $\text{K}_2\text{O}/\text{Na}_2\text{O}$ value in muds is 4.78 of Sample 19 collected at Tahara, Aichi Prefecture, and the minimum is 0.58 of Sample 48 at Orikasa, Iwate Prefecture; the maximum in sands is 3.64 of Sample 60 at Higashikiwa, Yamaguchi Prefecture, the minimum being 0.05 of Sample 88 at Sakawa, Kanagawa Prefecture. The average $\text{K}_2\text{O}/\text{Na}_2\text{O}$ value in muds is 1.30, which is similar to that in Korean muds, and lower than in red clays by ISHIBASHI and HARADA, shales and sandstones, but

higher than in red clays by HAMAGUCHI and igneous rocks. The average in sands is 0.90, which is similar to that in Korean sands and igneous rocks, and lower than in red clays by ISHIBASHI and HARADA, shales and sandstones, but higher than in red clays by HAMAGUCHI.

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