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XII. GEOCHEMISTRY OF ELEMENTS IN COASTAL MARINE SEDIMENTS FROM THE OFF SHIZUOKA, CENTRAL JAPAN

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Abstract

Heavy metals and some other elements were analyzed for 216 marine sediments from the Off Shizuoka. River sediments from the Shizuoka Prefecture were also analyzed for discuss the provenance of source material of the marine sediments. The marine sediments occurred around the Izu Peninsula have high amounts of Fe and other heavy metals, whereas the sediments around the Niijima and Kozushima, and western part of the Sea of Enshu are depleted in those metals, reflecting their source materials. The high Mn content more than 3000 ppm presumably arises from diagenetic enrichment. The unusual enrichment of Zn in the river sediments is considered to show recent environmental pollution, but the pollution for marine sediments is assumed to be negligible. Ultramafic rocks occurred in the catchment area of the Abe and Tenryu Rivers are the major significant sources of Ni and Cr to the studied marine sediments.

Introduction

In order to investigate the geochemical behavior of heavy metals in the coastal marine sediments, the authors have been analyzed for about 600 samples collected from the eastern margin of the Japan Sea (Terashima *et al.*, 1995a; Imai *et al.*, 1997). In this study, precise analytical data for 10 elements such as Fe, Mn, Cu, Pb, Zn, Ni, Co, Cr, V and Be in 216 marine sediments from the Off Shizuoka Prefecture will be reported. Major elements are also analyzed for selected 17 sediments. A brief summary of some geochemical characteristics such as interelement relationships, comparison with those of river sediments, and element sources are described. More detailed discussion will be presented elsewhere.

Samples and analytical methods

The sampling stations of marine sediments Off Shizuoka Prefecture are shown in Fig. XII-1. The sediments were collected using a grab sampler, and the uppermost part (ca. 0-1 cm) was selected for analysis. All the samples were dried for two days at about 80°C, and ground to under 100 mesh. Details of the sampling sites, occurrence and characteristics of the sediments are reported by Ikehara *et al.* (this cruise report), and a scale 1: 1,000,000 geological map of the survey area have been published (Okuda, 1977).

The 34 river sediments were collected from 10 representative rivers situated in the Shizuoka Prefecture. The sample was screened, and the fraction under 80 mesh was selected for analysis. Outline of the analytical method for Fe, Mn, Cu, Pb, Zn, Ni, Co,

Keywords: Off Shizuoka Prefecture, marine sediment, elemental distribution, geochemical behavior

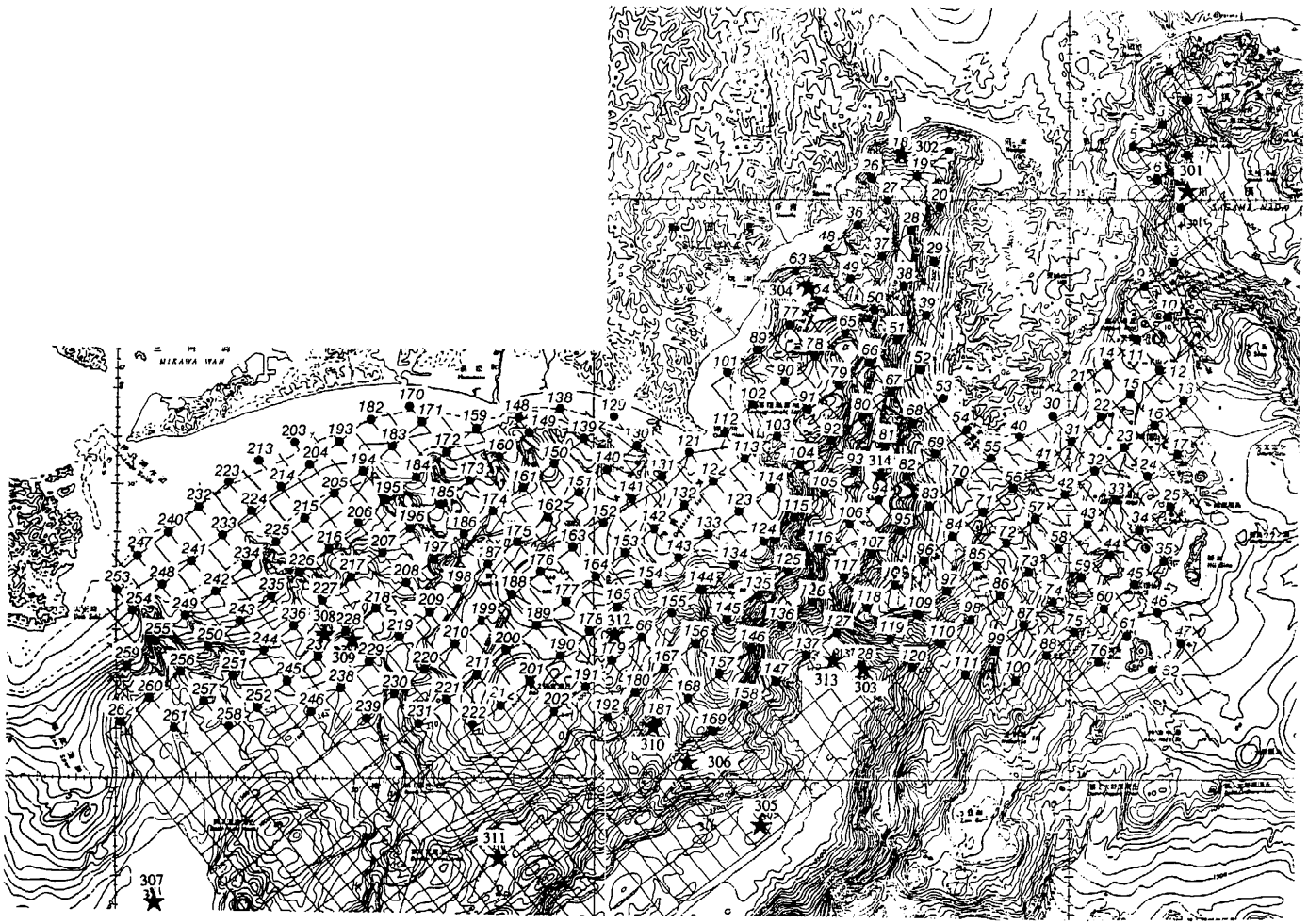

Fig. XII-1 Sampling stations for marine sediments in the off Shizuoka Prefecture.

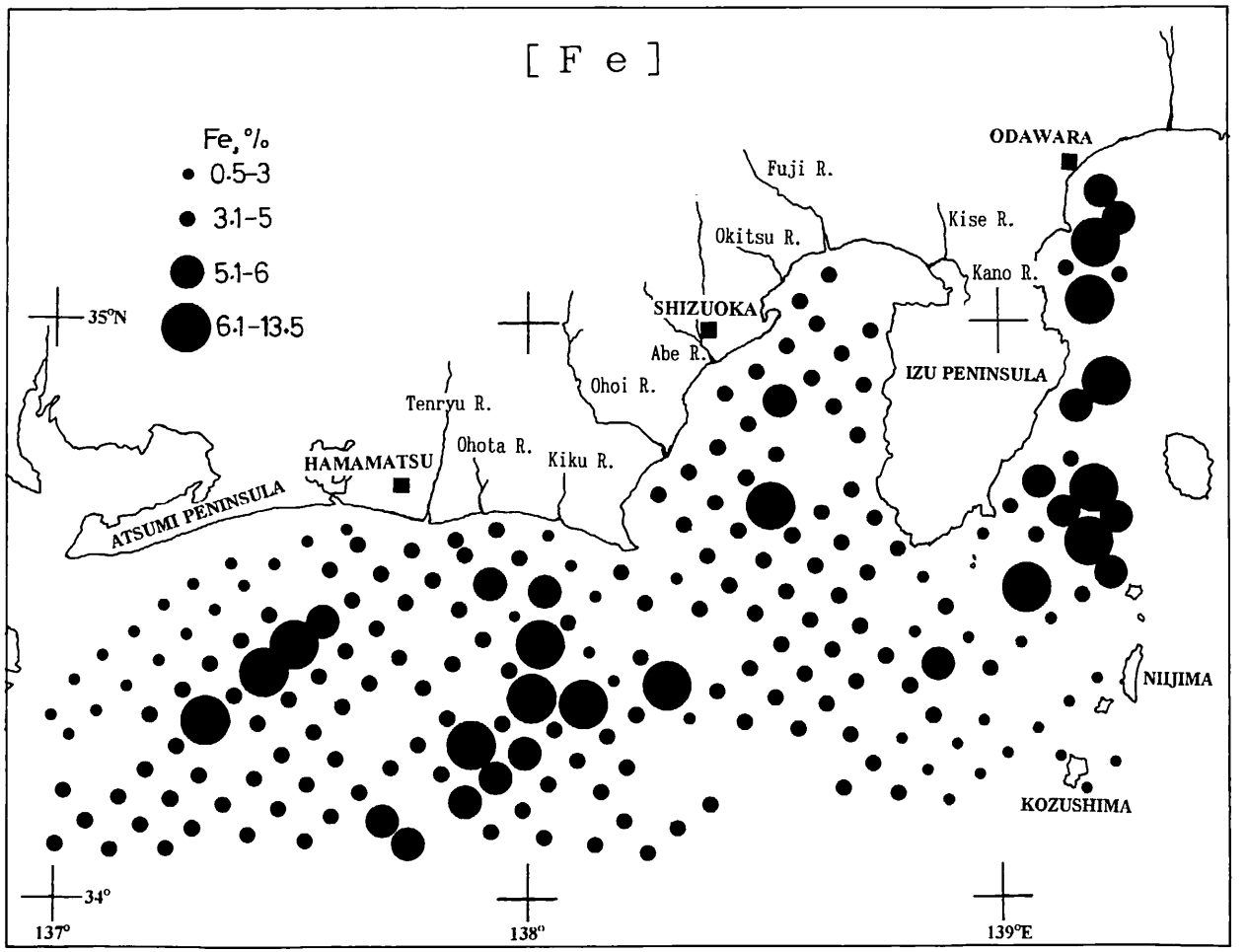

Fig. XII-2 Regional variation of Fe content in the sediments.

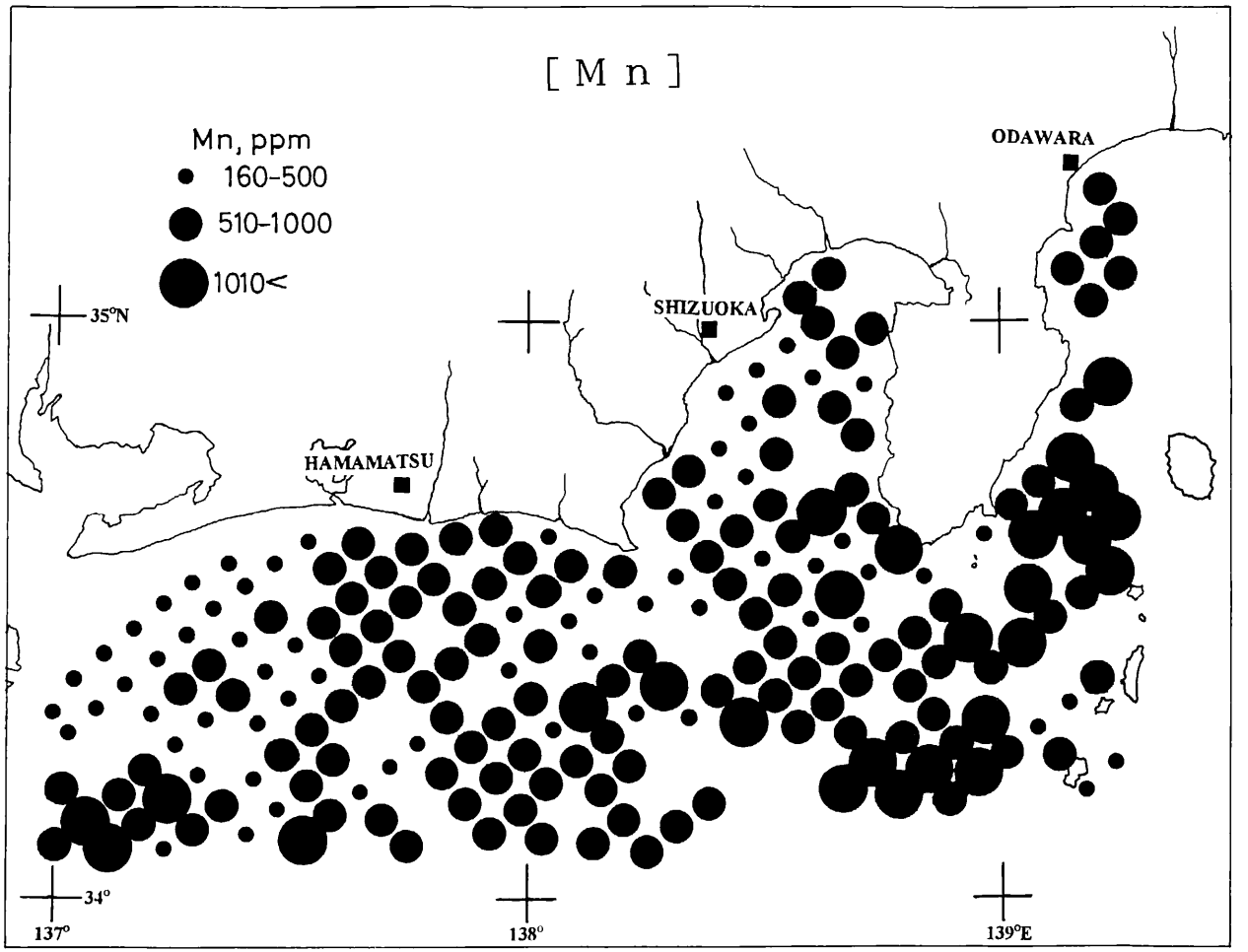

Fig. XII-3 Regional variation of Mn content in the sediments.

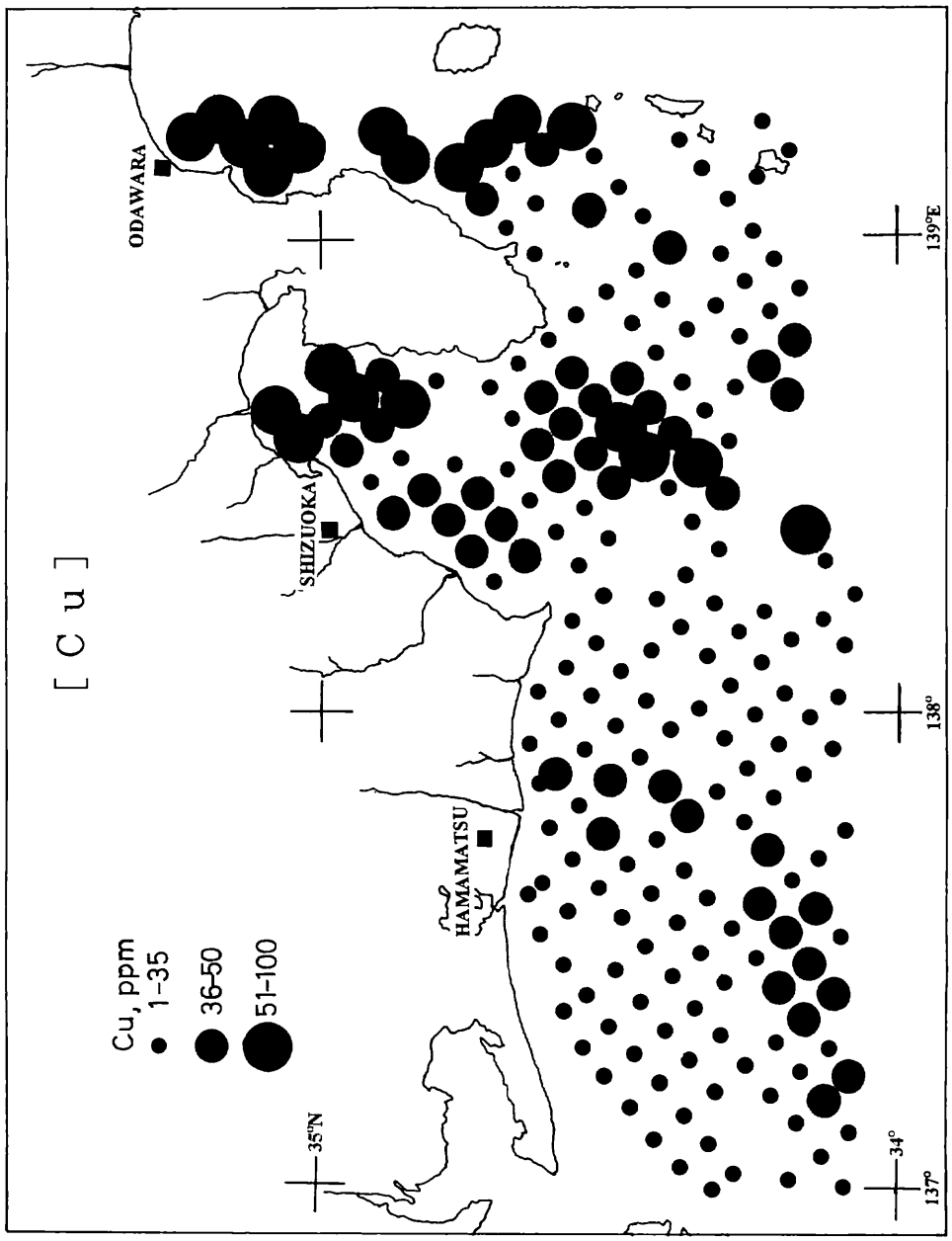

Fig. XII-4 Regional variation of Cu content in the sediments.

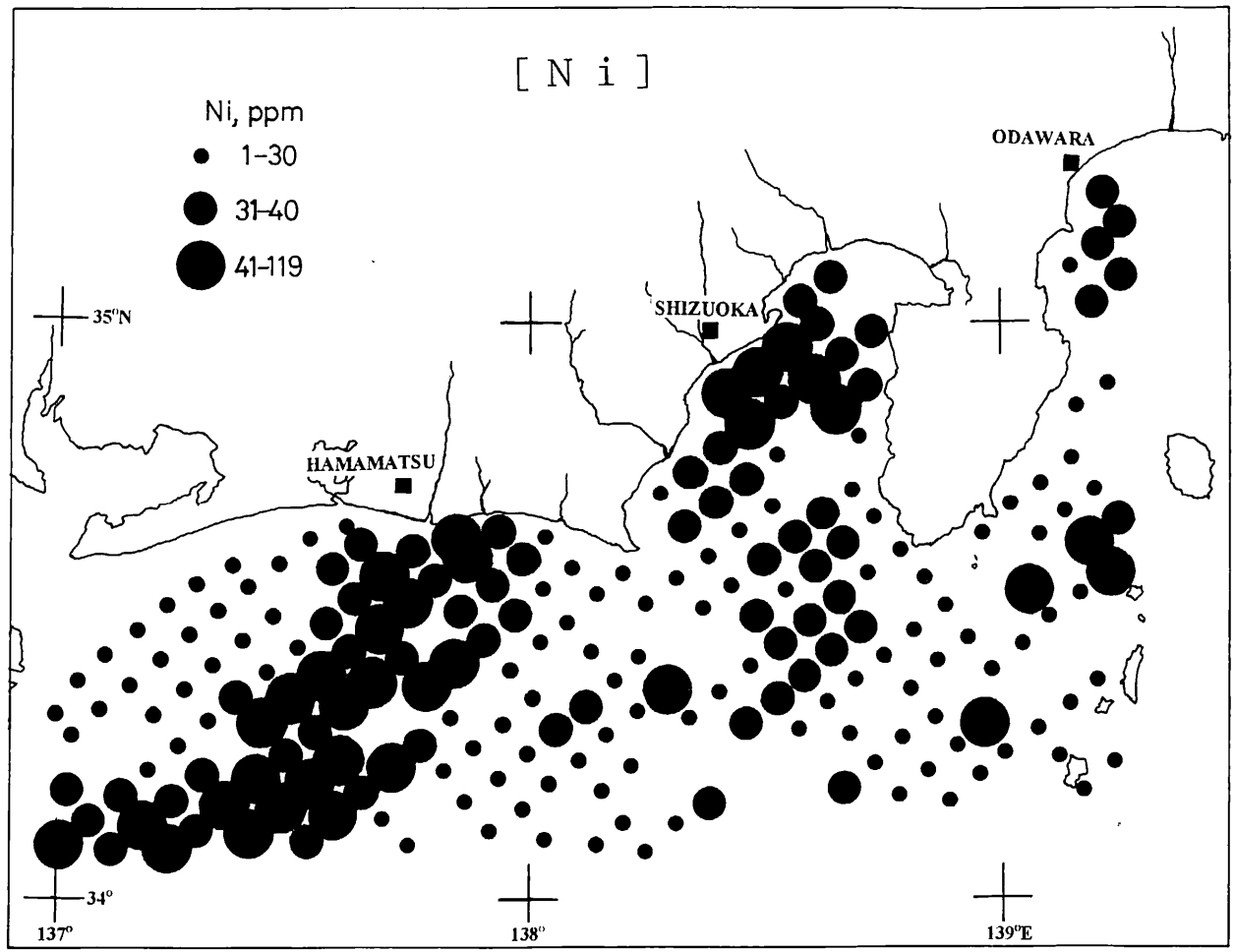

Fig. XII-5 Regional variation of Ni content in the sediments.

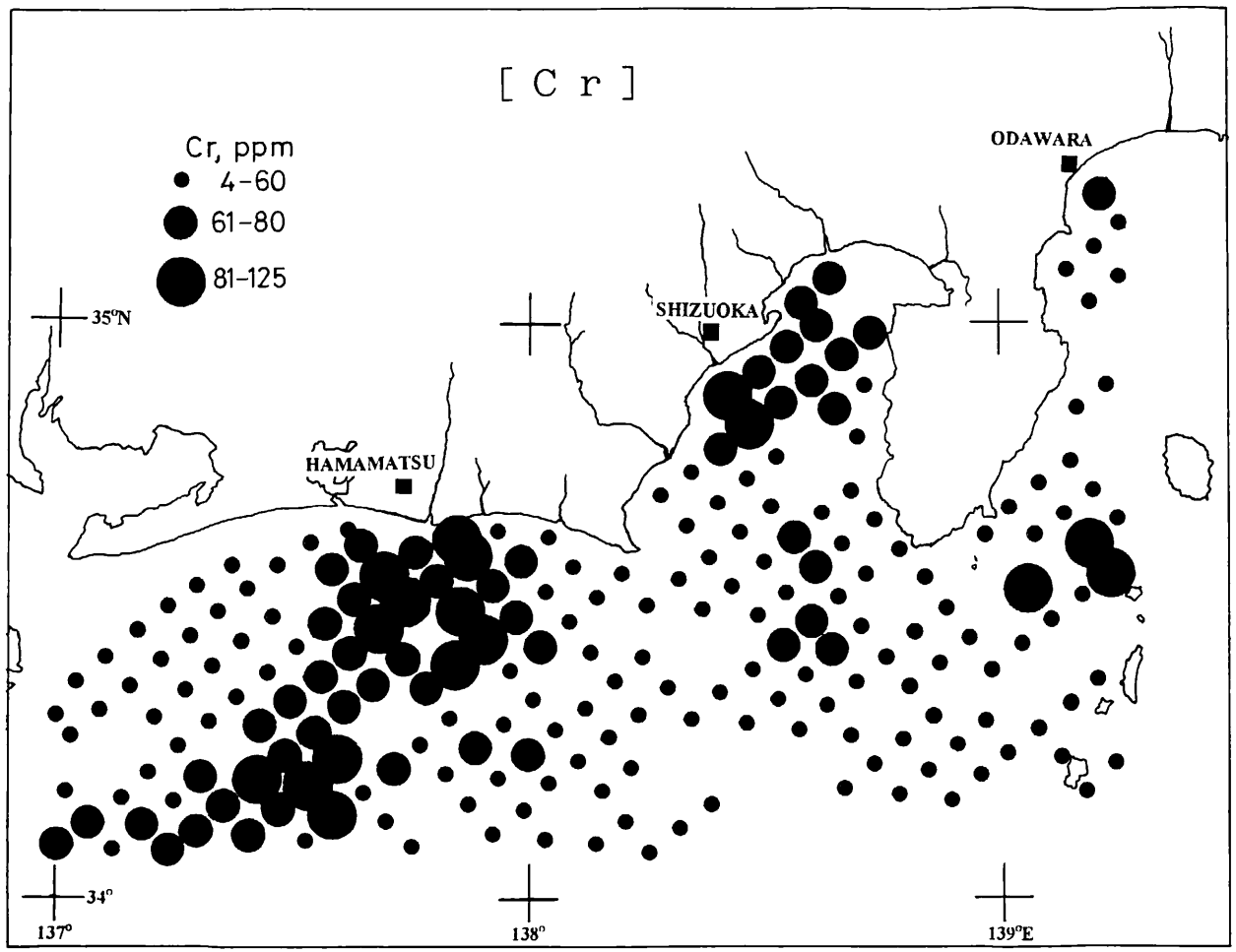

Fig. XII 6 Regional variation of Cr content in the sediments.

Cr, V, and Be in both marine and river sediments is given below.

The sample of 0.2 g was decomposed with a mixture of 2 ml of $HClO_4$, 2 ml of HNO_3 and 6 ml of HF in a platinum dish on a hot plate, and evaporated to dryness. The residue was dissolved by heating with 3 ml of 2 M HCl. After cooling, the solution was removed into a 10 ml calibrated flask and diluted to the mark with water. All the elements were determined by atomic absorption spectrometry using a nitrous oxide-acetylene flame for V and Be, and an air-acetylene flame for other metals. Analytical methods for major components were the same as in our previous paper (Terashima *et al.*, 1995b).

Results and Discussion

Fe and Mn

Analytical results of marine sediments are listed in Table XII-1. Regional Fe contents in the 216 sediments are shown in Fig. XII-2. Almost all the sediments from the East of Izu Peninsula have relatively high amounts of Fe. Whereas the sediments around the Niijima and Kozushima Islands, and western part of the Sea of Enshu are depleted in Fe. In order to investigate the source materials of studied marine sediments, major components are analyzed for selected 17 samples (Table XII-2). The major components for three sediments obtained in the East of Izu Peninsula are much similar to those of mafic volcanic rocks from the Izu Peninsula (Kurasawa, 1984). Therefore mafic volcanic rocks and related materials occurred in the Izu Peninsula are the major significant sources of the Fe rich sediments. The major element compositions of two sediments from around the Niijima and Kozushima Islands are nearly the same to those of rhyolitic rocks from the both Islands (Isshiki, 1982 and 1987). Four sediments from western part of the Sea of Enshu are relatively dominant in SiO_2 (70.8 to 77.7 % , Table XII-2), suggesting rather felsic source materials such as granitic rocks and/or sandstones.

Distribution of Mn concentrations in the marine sediments are shown in Fig. 3. The content of Mn varies greatly from 160 to 33800 ppm with an average of 880 ppm (Table XII-3). In general, the Mn content tends to increase with increasing water depth, reflecting the grain size of the sediments. The moderate abundance of Mn in the sediments from the East of Izu Peninsula is assumed to be mainly due to mafic volcanic rocks. The great enrichment of Mn more than 3000 ppm presumably arises from diagenetic enrichment (Terashima *et al*, 1995a).

Cu, Pb and Zn

The sediments from the East of Izu Peninsula and the Suruga Bay contain significant amounts of Cu as shown in Fig. XII-4. Analytical data of river sediments collected in the Shizuoka Prefecture are summarized in Table XII-4. The content of Cu in sediments from the three rivers Kano, Kise and Fuji Rivers which inflow into the eastern part of the survey area is much higher than that of other rivers. Mafic volcanic rocks and related materials occurred around the Izu Peninsula and the Mt. Fuji are the major significant sources of Cu to the sediments of the East of Izu Peninsula and the Suruga Bay.

As for the igneous rocks, it is generally accepted that most transition elements are

enriched more in mafic rocks than felsic ones, but such a trend cannot be recognized in the Pb content. In the case of marine sediments, however, the Pb content is correlated positively with some transition metals such as Fe, Zn, Ni, and Co ($r > 0.5$, Table XII-5). The significant amounts of Pb more than about 35 ppm may caused mainly by diagenetic enrichment.

The Zn content of the marine sediments studied (81 ± 23 ppm, Table XII-3) is more or less similar to crustal abundance (80 ppm). There is a clear positive correlation between the Zn content and Fe, Cu, Pb, Ni, Co, Cr and V content ($r > 0.6$, Table XII-5). The remarkable enrichment of Zn more than 400 ppm in the river sediments from Kano and Kise Rivers (Table XII-4) is considered to show recent environmental pollution. As for the marine sediments, however, the recent anthropogenic inputs to the Zn and other element contents are assumed to be negligible.

Ni and Cr

Ultramafic rocks such as dunite, peridotite and serpentine are generally enriched in Ni and Cr, and the rocks are easily altered during weathering in the supergene environment. Ultramafic rocks occurred in the catchment area of the Hime River are the major sources of Ni and Cr to the sediments of southeastern coastal margin of the Japan Sea (Terashima et al., 1995a; Imai *et al.*, 1997). Regional Ni and Cr contents in the studied marine sediments are shown in Figs. XII-5 and XII-6, respectively. Almost all sediments from the northern part of Suruga Bay and the central part of Sea of Enshu have significant amounts of Ni and Cr, and distribution patterns of the two elements are much similar. It is considered that ultramafic rocks occurred in the catchment areas of Abe and Tenryu Rivers are the major sources of Ni and Cr to the studied marine sediments.

Co, V and Be

The marine sediments around the Izu Peninsula are relatively dominant in Co and V (Table XII-1). The three river sediments collected from Kano, Kise and Fuji are also enriched in Co and V (Table XII-4). The major significant sources of Co and V in the regions are mafic volcanic rocks distributed in the Izu Peninsula and the Mt. Fuji. The Be content of the marine sediment varies from 0.3 to 3.3 ppm with an average of 1.5 ± 0.4 ppm (Table XII-3). In the case of igneous rocks, the Be is generally enriched more in felsic rocks than mafic rocks. The Be depleted sediments are only distributed in the East of Izu Peninsula (Table XII-1).

References

Imai, N., Terashima, S., Katayama, H., Nakajima, T., Ikehara, K. and Taniguchi, M. (1997) Geochemical behavior of heavy metals in coastal marine sediments from the eastern margin of the Japan Sea. *Bull. Geol. Surv. Japan*, **48**, 511-529 (in Japanese with English Abstract).

Isshiki, N.(1982) *Geology of the Kozushima districts. Quadrangle Series, Scale 1: 50,000*, Geol. Surv. Japan, 75p (in Japanese with English Abstract).

Isshiki, N.(1987) *Geology of the Niijima districts. Quadrangle Series, Scale 1: 50,000,*

Geol. Surv. Japan, 85p (in Japanese with English Abstract).

Kurasawa, H.(1984) Strontium isotopic consequence of the volcanic rocks from Fuji, Hakone and Izu areas (in Japanese with English Abstract). *Bull. Geol. Surv. Japan,* **35**, 637-659.

Okuda, Y.(1977) *Geological map off outer zone of southwest Japan, Marine geology map series 8, Scale 1: 1,000,000,* Geol. Surv. Japan.

Terashima, S., Nakajima, T., Katayama, H., Ikehara, K., Imai, N. and Taniguchi, M. (1995a) Geochemical behavior of heavy metals in marine sediments from the Off Akita-Yamagata, Japan Sea. *Bull. Geol. Surv. Japan,* **46**, 153-176 (in Japanese with English Abstract).

Terashima, S., Usui, A. and Imai, N.(1995b) Two new GSJ geochemical reference samples: Syenite JSy-1 and manganese nodule JMn-1. *Geostandards Newsletter,* **19**, 221-229.

Table XII-1 Analytical data for marine sediments.

Station No.	Fe (%)	Mn (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Cr (ppm)	V (ppm)	Be (ppm)	CO_2 (%)
1	5.88	840	90	22	111	37	22	61	186	0.8	
2	5.80	700	100	29	122	36	21	60	170	0.8	
3	6.41	990	90	28	120	39	27	58	215	0.9	0.85
4	5.00	590	74	38	131	34	19	58	155	1.0	
5	4.80	540	60	30	111	27	17	45	138	0.9	
6	6.40	910	73	26	122	33	25	59	196	0.9	
8	6.42	1100	73	17	97	27	26	41	240	1.0	
9	5.21	880	68	20	94	27	20	48	186	0.9	
11	4.51	1070	60	19	75	17	17	30	177	1.0	
12	7.39	1460	80	25	97	29	32	52	290	0.8	1.85
13	5.79	1150	72	24	78	34	26	58	206	0.9	
14	5.13	1000	48	22	85	22	19	45	174	0.9	
15	5.64	1270	32	26	96	17	20	31	190	0.9	
16	7.35	1820	43	26	103	77	40	125	240	0.9	0.71
17	5.51	2560	51	19	72	79	31	90	180	0.9	
18	4.72	670	64	25	113	39	18	65	132	1.7	
20	4.48	540	54	27	113	37	15	60	126	1.7	
21	3.74	760	15	25	81	15	13	27	96	0.9	
22	5.00	1100	24	22	85	15	19	28	174	1.0	
24	3.18	890	28	17	52	15	13	21	104	0.9	
26	4.38	560	52	26	110	38	15	62	133	1.7	
27	4.50	600	46	26	104	38	14	63	120	1.7	
28	4.65	610	55	29	115	40	19	65	125	1.8	
29	4.08	490	40	26	106	33	13	52	112	1.4	
30	2.08	500	12	22	41	5	5	15	58	0.7	26.02
32	8.33	3100	45	36	112	84	46	120	296	0.9	
33	2.00	730	17	16	38	4	7	14	58	1.2	1.57
35	0.75	610	3	10	25	2	1	7	12	1.4	1.96
36	3.74	480	40	25	98	50	14	72	106	1.8	
37	3.98	470	48	26	106	45	14	70	116	1.8	
38	4.31	540	52	31	113	43	16	63	122	1.9	0.27
39	4.17	540	30	26	100	27	14	44	106	1.4	
43	1.48	1180	14	17	40	5	7	14	32	1.2	3.81
45	0.68	460	2	7	21	1	1	7	12	1.0	0.46
47	0.70	490	1	8	30	2	1	5	11	1.4	0.62
48	3.62	490	25	18	102	53	21	72	92	1.8	
49	5.48	850	32	24	109	40	21	61	122	1.9	
52	3.80	520	28	24	90	27	13	44	100	1.5	
53	4.30	820	16	23	86	15	12	28	106	1.0	
54	5.00	1200	10	24	84	16	15	22	152	0.7	
55	1.35	390	10	36	42	15	4	16	48	0.3	29.80
56	3.70	810	20	20	72	16	12	22	90	0.9	
57	3.00	1300	28	23	59	15	10	21	90	0.9	5.56
58	3.05	1000	39	16	54	14	11	22	104	1.0	
60	0.69	500	2	4	25	2	1	5	8	1.0	0.61
61	1.20	590	2	4	35	2	1	5	26	1.1	0.94
62	0.46	440	1	2	20	1	<1	4	9	1.1	0.78
63	3.66	450	50	25	107	55	13	87	121	2.0	
64	3.68	480	50	26	109	52	14	88	123	2.0	0.33
65	3.55	610	14	19	78	24	11	48	85	1.5	
67	4.42	2400	32	23	92	38	31	55	115	1.8	
68	3.30	480	41	32	96	34	11	55	104	1.6	
69	3.35	500	39	24	85	30	11	52	116	1.8	
71	1.33	540	12	26	30	16	6	14	48	0.9	29.43
72	5.10	980	23	25	81	23	19	31	144	0.8	
74	2.83	33800	31	38	103	119	24	18	98	0.7	16.26
75	2.60	980	14	11	46	8	8	17	62	1.1	3.19
77	3.65	440	45	23	107	40	11	62	118	1.8	
78	3.56	480	40	25	107	38	10	60	101	2.0	

Table XII-1 (continued)

Station No.	Fe (%)	Mn (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Cr (ppm)	V (ppm)	Be (ppm)	CO_2 (%)
79	10.51	940	12	23	110	25	27	55	101	2.5	
80	3.82	510	45	30	96	40	13	63	120	2.0	
81	3.71	500	49	24	98	40	11	63	105	1.9	
82	3.50	2410	41	32	95	37	16	58	102	1.4	
83	3.28	500	40	27	85	31	11	54	104	1.4	
84	5.00	950	29	29	73	26	20	39	125	0.9	
85	4.50	860	28	23	79	19	16	38	125	0.9	
86	3.02	930	18	13	53	14	10	19	85	1.0	
87	1.28	700	9	9	39	6	5	10	37	1.0	0.98
88	2.41	1140	30	23	62	19	7	29	72	1.0	4.85
89	3.45	510	46	25	107	34	11	55	104	2.1	
90	3.46	500	39	25	99	35	11	55	105	2.0	
91	4.92	730	16	36	83	28	17	40	85	1.8	
92	3.40	450	39	27	96	37	11	60	103	1.6	0.86
93	3.80	640	38	15	83	28	13	60	127	1.5	
94	3.78	660	58	27	97	37	14	61	116	1.6	
95	3.30	480	42	27	95	37	11	61	108	1.8	
96	3.26	980	32	21	78	28	11	50	96	1.4	
98	2.74	940	26	10	54	15	10	28	88	1.3	2.45
99	2.68	1220	28	20	55	17	10	27	80	1.1	5.16
100	2.88	980	29	20	64	14	11	25	78	1.4	5.31
101	3.13	530	18	18	75	19	10	39	74	2.0	
102	3.87	530	38	33	107	31	11	53	98	2.3	
103	3.40	700	23	22	93	27	10	50	76	1.5	0.94
104	3.80	560	33	24	97	29	9	55	89	1.6	
105	3.99	600	41	30	105	33	12	60	98	1.6	
106	4.48	680	60	31	113	40	17	63	128	1.8	
107	4.12	840	40	26	95	35	11	56	102	1.6	
108	3.33	840	25	19	69	24	10	47	85	1.5	
109	4.78	850	30	20	80	21	14	44	120	1.5	
110	3.10	1350	36	14	69	23	11	37	91	1.4	
111	3.32	1070	38	20	75	26	12	41	92	1.4	
113	2.79	480	10	15	59	17	9	44	62	1.4	3.57
114	3.30	400	9	12	49	15	5	38	43	1.1	
116	3.65	850	33	20	82	27	12	47	96	1.6	
117	4.15	700	52	24	100	35	11	56	105	1.6	
118	3.32	890	29	19	75	26	11	45	93	1.6	
120	3.41	1560	43	21	85	36	11	45	100	1.5	
121	4.77	830	15	31	70	16	9	33	73	1.3	
122	4.33	480	9	30	76	15	13	27	44	1.4	
125	3.00	520	20	20	77	25	9	50	80	1.6	1.37
126	3.93	1700	42	22	94	36	18	54	106	1.7	
129	2.50	500	9	18	55	25	7	48	52	1.5	0.37
130	2.78	520	11	15	67	20	11	50	58	1.5	1.95
131	2.78	470	10	15	59	14	8	40	44	1.3	4.79
133	3.20	540	9	33	54	16	9	25	48	1.1	
134	10.85	5900	12	66	122	85	67	46	108	1.9	
135	1.78	280	9	8	40	9	3	26	42	1.1	3.28
138	3.10	760	13	20	75	32	12	54	70	1.6	
139	3.36	580	21	20	85	33	12	61	82	1.9	
140	5.15	610	15	20	85	28	15	57	78	1.9	
141	3.28	490	15	17	82	27	10	55	77	1.7	
142	2.90	470	8	33	62	22	10	26	46	0.9	22.51
143	1.72	530	11	33	47	18	6	21	40	0.9	23.62
144	3.55	480	13	19	66	21	9	43	66	1.6	
147	4.01	670	53	20	99	38	13	60	114	1.8	
148	3.52	580	29	21	87	41	14	84	86	1.9	
149	3.87	540	42	30	111	49	15	100	105	1.9	0.79
150	5.31	530	19	20	90	35	16	70	77	1.9	
151	3.47	480	28	20	93	39	11	78	88	1.8	

Table XII-1 (continued)

Station No.	Fe (%)	Mn (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Cr (ppm)	V (ppm)	Be (ppm)	CO_2 (%)
152	7.50	570	13	19	90	28	21	67	73	2.5	
154	7.66	1980	12	46	93	40	35	46	90	1.8	
155	3.21	650	23	19	76	28	9	51	80	1.7	
156	3.20	800	25	19	71	28	11	49	83	1.6	
158	3.70	760	20	12	70	19	13	39	101	1.2	
159	3.41	580	22	15	85	38	14	72	80	2.0	
160	4.60	550	20	20	93	39	17	79	80	1.8	
161	3.48	600	38	14	85	40	14	90	84	1.8	0.38
162	3.52	610	35	17	90	40	14	82	90	1.8	
163	4.11	470	12	13	65	20	12	43	59	1.6	
164	6.25	620	9	17	76	24	20	49	80	1.8	
165	3.28	470	30	17	84	32	9	57	93	1.8	
166	4.78	720	20	29	80	27	15	54	89	1.8	
167	3.18	730	27	17	70	26	12	47	89	1.6	
168	3.80	720	25	17	75	26	14	50	104	1.7	
169	4.59	730	21	20	76	25	15	46	101	1.7	
170	2.96	580	12	17	70	30	13	60	70	1.8	0.57
171	3.50	580	19	17	85	39	15	71	78	1.8	
172	3.62	590	21	17	87	41	14	83	80	1.8	0.43
173	3.70	510	39	18	96	49	14	104	96	1.8	
175	3.63	580	42	19	91	47	14	92	84	1.8	
177	3.22	610	11	13	65	25	9	54	61	1.7	
178	5.50	610	13	15	73	23	13	63	70	1.9	
179	3.61	670	19	20	73	25	12	51	73	1.6	
180	3.06	730	29	20	79	30	12	52	80	1.5	
182	2.60	430	8	13	65	20	12	45	44	1.4	0.35
183	3.69	520	15	17	82	38	14	71	74	1.8	
184	3.61	520	15	16	83	38	12	71	75	1.8	
185	3.61	600	33	20	92	48	13	88	90	1.8	
186	3.80	820	23	19	84	36	13	69	78	1.8	
187	3.99	540	36	27	94	43	11	80	90	1.6	
188	3.54	710	16	19	70	27	9	54	71	1.5	
189	7.70	720	12	25	86	21	21	73	140	1.8	
190	5.80	600	12	27	73	22	16	53	80	1.6	
191	4.24	710	22	21	67	20	11	42	90	1.4	
192	3.50	720	22	25	72	28	10	48	88	1.6	
193	2.81	320	6	19	64	16	11	37	49	1.6	0.71
195	5.72	520	19	23	88	37	14	79	87	2.0	
196	5.00	730	21	27	88	35	14	70	88	1.7	
197	3.65	570	28	22	82	41	13	80	85	1.6	
199	3.60	410	28	24	85	32	8	60	84	1.6	
200	4.24	650	16	25	71	25	11	47	73	1.5	
201	5.10	630	15	41	75	27	15	47	82	1.7	
202	3.71	720	20	24	74	24	9	45	74	1.6	
203	1.40	230	3	13	27	2	4	17	20	0.9	0.15
204	2.81	350	6	16	61	14	9	34	40	1.5	1.00
205	4.06	620	10	18	86	23	14	51	74	1.7	
206	11.00	450	10	24	92	30	25	59	66	3.1	
207	3.62	500	30	25	89	42	11	79	89	1.6	
208	3.58	510	31	25	87	41	9	76	85	1.6	
210	3.45	450	37	25	96	42	9	66	97	1.7	
213	1.06	160	5	7	16	8	2	47	22	0.6	1.11
214	2.64	310	6	19	57	14	7	38	48	1.4	0.86
215	3.15	400	9	18	68	22	9	48	58	1.5	
216	13.50	340	9	37	108	27	28	50	70	3.3	
217	3.78	480	35	25	97	44	10	80	93	1.6	
218	3.80	720	28	26	85	40	12	76	88	1.7	
219	4.34	530	42	25	97	52	13	92	100	1.7	
220	3.15	440	25	19	74	32	10	60	80	1.6	
221	5.47	780	16	24	74	23	14	49	77	1.6	

Table XII-1 (continued)

Station No.	Fe (%)	Mn (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Cr (ppm)	V (ppm)	Be (ppm)	CO_2 (%)
222	5.71	680	20	34	76	25	16	45	108	1.3	
223	1.86	300	4	14	45	7	7	24	38	1.2	0.49
224	2.37	340	5	19	50	7	7	28	40	1.3	0.98
225	4.22	520	8	19	93	18	13	41	65	1.6	
226	3.51	560	20	19	85	31	12	57	77	1.6	
227	3.51	480	35	26	96	43	13	77	95	1.6	
228	4.78	760	30	25	89	34	13	67	90	1.9	
229	3.81	510	38	26	97	44	11	83	99	1.7	
230	4.00	1270	40	25	95	45	14	83	96	1.7	
232	1.56	380	2	15	32	7	4	25	30	1.2	0.35
233	2.31	400	5	16	60	6	7	27	30	1.2	0.86
234	4.37	710	6	16	110	15	19	35	70	1.7	
235	12.78	480	6	48	116	23	29	60	105	2.5	
237	3.60	470	39	25	100	45	10	82	94	1.8	
238	3.47	440	39	24	95	44	9	67	86	1.7	
239	3.44	1280	30	24	84	33	10	55	82	1.6	
240	0.90	220	2	5	20	1	2	11	8	0.8	0.33
241	2.56	440	5	18	62	6	8	23	46	1.7	1.19
242	4.30	460	7	18	114	16	16	33	50	1.3	
243	3.62	400	12	16	73	17	9	46	58	1.6	
244	3.23	440	29	18	85	38	9	69	86	1.6	
245	3.55	610	38	23	97	43	10	75	87	1.8	
245	3.38	440	40	24	96	43	9	72	92	1.6	
247	1.41	350	3	12	42	4	4	20	26	1.0	0.53
248	2.00	350	5	14	52	6	6	24	40	1.1	0.90
250	3.40	660	22	18	81	30	10	59	77	1.5	
251	4.32	1030	27	26	95	36	14	60	95	2.0	
252	3.38	900	34	23	88	38	10	61	80	1.3	
253	1.15	230	4	10	35	3	5	16	22	0.9	0.43
254	2.01	400	8	11	50	4	6	26	47	1.1	0.69
256	3.12	530	25	22	82	31	9	58	75	1.6	
257	3.54	680	37	18	92	42	12	65	84	1.6	
258	3.32	480	40	17	93	42	10	68	84	1.7	
259	3.30	540	23	17	83	33	9	61	78	1.7	
260	3.32	1060	34	21	88	39	12	69	80	1.7	
261	3.12	1270	30	19	83	34	10	60	78	1.6	
262	3.35	520	35	17	93	44	10	75	86	1.8	

Table XII-2 Analytical data of major components for selected 17 marine sediments.

Station No.	Sediment	SiO_2 (%)	TiO_2 (%)	Al_2O_3 (%)	T-Fe_2O_3 (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	LOI (%)	Total (%)	CO_2 (%)
East of Izu Peninsula													
3	Coarse sand	48.2	0.83	14.7	9.17	0.12	3.97	7.19	4.23	0.98	10.13	99.52	0.85
12	Fine sand	52.1	0.81	13.3	10.57	0.18	4.03	9.51	3.14	0.95	5.38	99.96	1.85
16	Medium sand	51.0	0.85	16.2	10.51	0.22	5.61	9.12	3.20	0.69	2.75	100.13	0.71
Around Niijima-Kozushima													
35	Fine sand	68.0	0.11	11.5	1.07	0.08	0.54	3.56	4.98	2.85	7.38	100.08	1.96
62	Medium sand	75.8	0.07	11.5	0.66	0.06	0.29	2.20	4.16	2.68	2.75	100.17	0.78
Suruga Bay													
38	Silt	56.2	0.55	14.5	6.16	0.07	2.70	1.97	4.31	2.54	10.90	99.90	0.27
64	Silt	61.2	0.53	14.7	5.26	0.06	2.37	1.12	3.50	2.85	7.88	99.42	0.33
92	Silty clay	56.7	0.47	13.2	4.86	0.06	2.26	2.67	4.41	2.65	12.23	99.52	0.86
103	Fine sand	63.5	0.45	12.7	4.86	0.09	1.81	2.50	3.69	2.67	7.41	99.67	0.94
Enshunada(Eastern part)													
131	Fine sand	63.5	0.26	9.1	3.98	0.06	1.38	8.20	2.84	1.66	8.80	99.76	4.79
149	Silty clay	58.0	0.49	14.6	5.53	0.07	2.50	2.00	3.76	2.89	9.75	99.62	0.79
161	Fine sand	65.1	0.47	13.3	4.98	0.08	2.25	2.13	3.50	2.61	4.94	99.39	0.38
172	Fine sand	63.4	0.49	13.3	5.18	0.08	2.31	2.39	3.52	2.68	6.09	99.46	0.43
Enshunada(Western part)													
204	Fine sand	72.3	0.25	9.7	4.02	0.04	1.50	2.50	2.57	2.50	4.60	99.98	1.00
232	Fine sand	77.7	0.21	9.9	2.23	0.04	0.91	1.62	2.73	2.49	2.30	100.12	0.35
241	Fine sand	70.8	0.33	10.0	3.66	0.06	1.31	3.50	2.56	2.77	4.71	99.72	1.19
254	Fine sand	74.6	0.33	9.9	2.87	0.06	1.05	2.39	2.56	2.57	3.29	99.62	0.69

T-Total; LOI-Loss on ignition

Table XII 3 Average, standard deviation, minimum, and maximum chemical composition for marine sediments (n = 216).

	Fe (%)	Mn (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Cr (ppm)	V (ppm)	Be (ppm)
Average	3.89	880	27	22	81	29	13	51	91	1.5
Standard deviation	1.80	2310	18	8	23	16	7	22	44	0.4
Minimum	0.46	160	1	2	16	1	<1	4	8	0.3
Maximum	13.50	33800	100	66	131	119	67	125	296	3.3

Table XII-4 Analytical data for river sediments.

River name	Number of sample	Fe (%)	Mn (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Ni (ppm)	Co (ppm)	Cr (ppm)	V (ppm)	Be (ppm)
Kano R.	1	8.09	1260	133	27	403	50	34	74	307	0.7
Kise R.	7	6.99	1356	210	50	412	54	32	84	268	0.8
Fuji R.	10	5.39	980	109	27	130	40	23	70	200	1.3
Okitsu R.	1	4.40	740	52	28	111	23	16	44	132	0.9
Abe R.	4	3.60	558	50	20	107	68	14	87	95	1.8
Seto R.	2	2.90	535	56	41	181	40	12	65	78	1.6
Ohoi R.	4	3.11	675	43	22	103	28	11	44	87	2.1
Kiku R.	1	2.86	330	36	20	146	27	11	55	59	1.7
Ohota R.	1	2.98	590	46	20	143	32	14	56	78	1.7
Tenryu R.	3	3.61	890	67	27	158	50	16	82	92	1.8

Table XII-5 Correlation coefficient matrix for marine sediments (n = 216).

	Fe	Mn	Cu	Pb	Zn	Ni	Co	Cr	V
Mn	0.05								
Cu	0.26	0.05							
Pb	0.59	0.23	0.32						
Zn	0.62	0.11	0.66	0.61					
Ni	0.38	0.47	0.52	0.52	0.71				
Co	0.82	0.26	0.36	0.60	0.60	0.58			
Cr	0.39	-0.08	0.47	0.29	0.69	0.77	0.38		
V	0.56	0.11	0.78	0.42	0.65	0.51	0.68	0.44	
Be	0.41	-0.15	-0.04	0.20	0.46	0.32	0.15	0.52	-0.11