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Article

Geochemical variation of the Late Cretaceous-Paleogene granitoids across the Ehime-Hiroshima-Shimane transect, Japan

Shunso Ishihara[1,*] and Tetsuji Ohno[2]

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Abstract: Geochemical and geomagnetic character of the Late Cretaceous-Paleogene granitic batholith was examined at N-S transect across the city of Hiroshima. The granitoids are mostly biotite granite in composition, but granodiorite predominates in the Takanawa Peninsula. Their magnetic susceptibility is the highest in the Sanin belt, but becomes lower of the ilmenite-series to the south and lowest in the southernmost Ryoke belt. The granitoids are most sodic in the Sanin belt and potassic in the Sanyo and Ryoke belts, which may reflect igneous and sedimentary source rocks, respectively. The alumina saturation index (A/CNK) is above 1.0, i.e., peraluminous, but never exceeding 1.1 for S-type granite. Rb and Pb replacing K are the least in the Sanin belt but the highest in the Ryoke and southern Sanyo belts. High-Sr granitoids and adakite of the northern Kyushu and the Kinki district were not found in the studied regions. Zircon saturation temperatures in the average of the studied granitoids are the highest of 753°C in the Ryoke belt, because granodiorite predominates here.

Keywords: Granitoids, magnetite-/ilmenite-series, petrochemistry

1. Introduction

Granitic rocks occur most widely in the Inner Zone of Southwest Japan. When their radiometric ages became available, the granitoids were found to have older, Late Cretaceous in age (95-75 Ma, K-Ar) in its southern parts of the Sanyo and Ryoke belts, and younger, Paleogene age (60-50 Ma, K-Ar) in the Sanin belt toward north (e.g., Kawano and Ueda, 1966). Recent U-Pb ages on zircon indicate also younging ages from 98-95 Ma in the Ryoke belt, 92-86 Ma in the Sanyo belt, and to 64-33 Ma in the Sanin belt, mainly on the Matsuyama-Hiroshima-Shimane transect (Tani *et al*., 2014). They were essentially different in the rock-forming oxide minerals; magnetite-bearing in the Sanin belt and magnetite-free in the Sanyo and Ryoke belts (Ishihara, 1971, 1979), and also on the contained mafic silicate minerals (Czamanske *et al*., 1981) and apatite (Ishihara and Moriyama, 2016).

These granitoids intrude into the late Paleozoic and Jurassic metamorphic and sedimentary rocks, and the Late Cretaceous volcanic-sedimentary rocks. Exposures of the granitoids are sporadic, no continuous outcrop from the Sanyo belt to the Sanin belt in general, but one at the Oasa township in the very northern of the Hiroshima Prefecture (Fig. 1). Therefore, the granitoid samples were collected there and dated by K-Ar method on the biotites, and found to have older than 80 Ma toward south and 64 to 38 Ma toward the north of Oasa township (Shibata and Ishihara, 1974), and cross-cut relationship was found at north of Oasa and studied by Higashimoto (1975).

Recently, U-Pb zircon age determination was performed on 92 granitoid samples across the eastern Chugoku District, about 120 km east of our studied region (Iida *et al*., 2015). They emphasized a stepwise decreasing on the measured ages northward from 95 to 30 Ma, with a distinct time gap between 60 and 48 Ma, although no intrusive relationship between each body has been observed. Besides the ages, regional variations of Fe_2O_3/FeO ratio (Ishihara, 1971), magnetic susceptibility (Ishihara, 1979), $\delta^{18}O$ in quartz (Honma and Sakai, 1976) of the granitoids have been reported in the Chugoku District. There may be some other variations on the chemical compositions.

This paper intends to clarify the regional variations on

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[1] AIST, Geological Survey of Japan, Research Institute of Geology and Geoinformation

[2] AIST, Geological Survey of Japan, Research Institute for Georesources and Environment

*Corresponding author: S.Ishihara,Central 7,1-1-1 Higashi, Tsukuba, Ibaraki 305-8567, Japan. Email: s-ishihara@aist.go.jp

chemistry of these granitoids, and to consider the genetic background of these parameters. Locations of the analyzed samples are shown in Figure 1, and the sample locality and magnetic susceptibility data are described in Appendix 1.

2. Geological background of the studied area

The studied areas across the Late Cretaceous plutonic rocks of the western Shikoku and the Late Cretaceous to Paleogene ones of the central Chugoku districts are shown in Figure 1. The studied rocks are listed in Appendix 1, and their chemical compositions are given from south to north in Tables 1 to 5. The rocks are mostly granitic in composition; mafic plutonic rocks occur very locally at the tip of the Takanawa Peninsula and in the Kitahiroshima-cho to the north of Hiroshima city.

2.1 Ryoke belt granitoids

The southernmost part of the studied granitoids are those in the Takanawa Peninsula, which are considered to belong mostly to the Ryoke metamorphic and plutonic rocks (Hirokawa, 1965; Okamura, 1967), except for biotite granites around the northern tip where occurring together metasomatic syenites (Murakami, 1959) and rare metal-bearing pegmatites (Minagawa *et al*., 1978, 2001; Sato *et al*., 2014), both of which are characteristic of the Sanyo belt granitoids (e.g., Aoki and Hida, 1974). The Ryoke granitoids were once classified as “older” and “younger” (Miyahisa and Hiraoka, 1970) without any radiometric age data.

The plutonic rocks are composed of magnetite-free rocks of tonalite and granodiorite mostly with some amounts of granites and then a little gabbroid (Ochi, 1982). They are mineralogically magnetite-free I-type granitoids, but garnet-bearing two mica granites are present very locally to the northwest in the Yanai district of Yamaguchi Prefecture. In the Takanawa Peninsula, the alumina-saturation index (A/CNK, Table 1) is below the limit of S type of 1.1, thus I type. The magnetic susceptibilities as measured by Bison 3101 Model are very low, even on the low silica rocks (Appendix 1 and Table 1). Whole-rock $\delta^{18}O$ ratios of these granitoids are high as 10 to 11 ‰ regardless of the silica contents, and initial Sr ratio is 0.70773 with an Rb-Sr age of 92.6 ± 3.8 Ma (Honma *et al*., 1983).

Recent U-Pb age dating on zircon indicates that the ages vary from 97.8 ± 1.1 Ma to 95.3 ± 1.1 Ma (Tani *et al*., 2014, and unpublished data), which are the oldest among the studied granitoids of the whole region. The granitoids are older than similar granitoids exposed to the east in Kagawa Prefecture of the same Shikoku Island. Eleven plutonic rocks were studied chemically including two gabbroids and one syenite (Table 1).

2.2 Sanyo belt granitoids

To the north, there occur granitoids of the Sanyo belt, which are also called as Kure Granite around Kure city (Higashimoto *et al*., 1985) and Hiroshima Granite around Hiroshima city. They are magnetite-free in the opaque minerals (i.e., ilmenite series) and are characterized by pink colored K-feldspar. U-Pb ages of zircon are 92.1 ± 0.8 and 92.3 ± 1.0 Ma at Kure and Kurahashi-jima (Tani *et al*., 2014), where biotite granite mainly and lesser amount of granodiorite are exposed (Higashimoto *et al*., 1985). The central part of the Hiroshima Granite around Hiroshima and Kabe regions to the north have slightly younger in the zircon U-Pb age of 87.3 ± 0.9 to 85.6 ± 1.0 Ma (Tani *et al*., 2014). The rock assemblage is similar but contains xenolithic mass of gabbroids (sample nos.73H72 and 73H89, Table 3).

The Hiroshima granites as a batholithic intrusion are composed of medium-grained hornblende-bearing biotite granite, medium- to coarse-grained biotite granite and fine-grained biotite granite, containing xenolithic gabbroids very locally. Oxygen isotopic ratios, $\delta^{18}O$ values of quartz of the granitoids, decrease north from 13 ‰ at the Ryoke metamorphic belt, to 9 ‰ around the Kabe area (Honma and Sakai, 1976). Small pegmatites often occur in the Seto Inland Sea region, which can contain rare metal minerals (Sato *et al*., 2014), and productive amounts of Be-bearing minerals, such as phenacite hosted in the skarn body and danalite in the intruded alkaline granites at Mihara mine (Aoki and Hida, 1974).

Based on the sheet mapping results of 1:50,000 scale of Higashimoto *et al*. (1985), Takahashi *et al*. (1989) and Takahashi (1991), Takahashi (1993) emphasized in the Hiroshima city area that the main part is vertically zoned pluton, consisting of upper coarse-grained and lower medium-grained granites, although the SiO_2 contents vary only from 76 to 71%. The coarse-grained granite appear to be later than the medium-grained one, then fine-grained one is the youngest. These intrusive sequences have also been observed in the Kaitaichi Quadrangle (Takagi and Mizuno, 1999), although the age variation has not been given to the sequence. In the Daito-Yamasa region of the Sanin district, the marginal leucogranites gave older zircon ages of 65.3 and 64.2 Ma, while coarse-grained batholithic granite and granodiorite were dated at much younger ages of 59.7 Ma and 56.6 Ma, respectively (Ishihara and Tani, 2013). Thus, similar age determination is necessary in the Hiroshima region.

Hayashi (1995) found in the Togouchi-Yuu-Takehara region that the Hiroshima Granite is not a uniform body but accumulated layered bodies. Relatively mafic granites as granodiorite or hornblende-bearing granite occur above tabular body of biotite granites. He concluded that the Hiroshima granite as a whole tabular body dipping gently southward, intruded into the Late Cretaceous volcanic rocks after the rhyolitic eruption of the

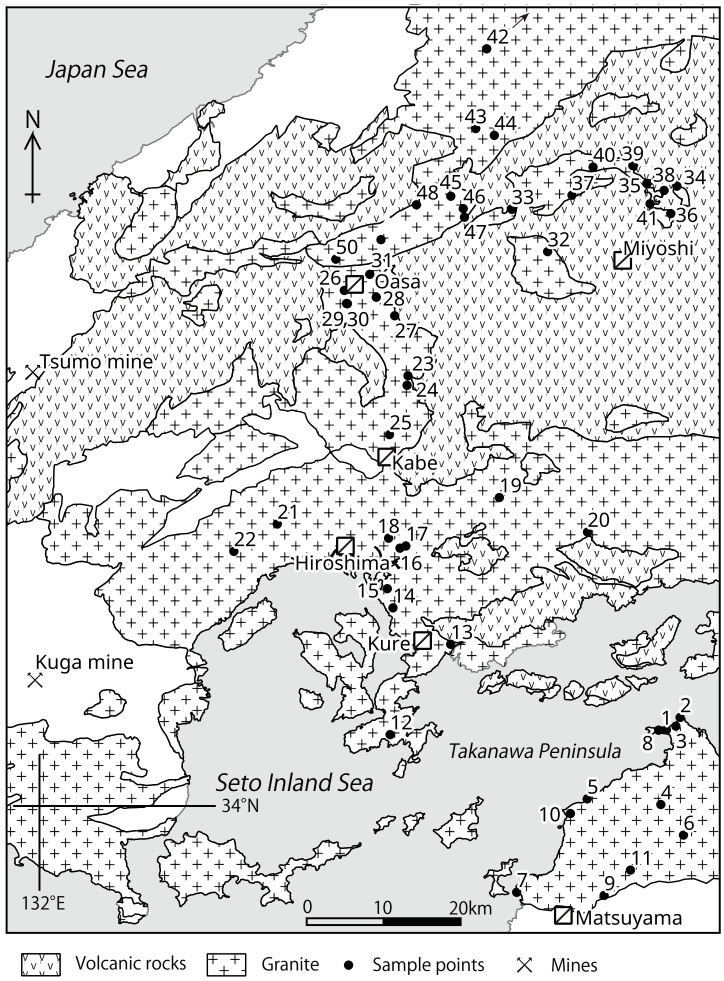

Fig. 1 Distribution of granitoids along the Hiroshima transect of central Chugoku District.

Takada Rhyolites.

To the north of Oasa township, similar granitoids are continuously exposed from the Sanyo belt (Hiroshima Pref.) to north of the Sanin belt (Shimane Pref.). Shibata and Ishihara (1974) determined the K-Ar ages on the biotites, and found the abrupt change from 80 to 38 Ma at north of the Oasa township, which were recalculated later by the new decay constant as 82 and 39 Ma, respectively (Sato *et al*., 1992).

Higashimoto (1975) followed up the results and found that an E-W trending vertical boundary of the two granitoids at 700 m NE of Nobori community at northwest of Oasa township. Here, the southern coarse-grained granite, strictly monzogranite by his modal analyses, which belongs to the Hiroshima Granite with the Late Cretaceous age, was intruded by the northern aplitic-porphyritic granite, strictly syenogranite by modal analyses, of the Paleogene in age.

Rezanov *et al*. (1994) adopted a whole-rock Rb-Sr isochron dating method for the same area, and obtained 72.9 ± 2.8 Ma of the internal isochron age on the Oasa Granite, which was strangely younger than K-Ar biotite age of 80.2 ± 3.2 Ma (Shibata and Ishihara, 1974). A further radiometric dating is needed.

To the east of Oasa, several small granitic bodies occur in Aki-takata city and Miyoshi city region, which give K-Ar biotite ages of 72 Ma at Tokorogi on the Shikijiki Granite and 87 Ma of Miyoshi region (Kawano and Ueda, 1966). Matsuura (1989) added K-Ar biotite age of 84.7 ± 4.2 Ma for the Shikijiki granite, and Rezanov *et al*. (1994) reported a whole rock isochron age of 80.5 ± 3.9 Ma for the same intrusive body.

To further northeast, Takagi *et al*. (1989) identified the Rb-Sr whole-rock-mineral isochron ages of 80.4 ± 3.3 and 83.4 ± 4.4 Ma on the two granitic stocks of Mitsumori and Ikuridani granites, which constitute the basement for Miocene U-bearing sediments (Ishihara *et al*., 1969). Takagi *et al*. (1989) considered the Mitsumori is typical magnetite-series while the Ikuridani is typical ilmenite-series granites. However, their data on the

Table 1 Chemical compositions of plutonic rocks of the Ryoke belt: Takanawa Peninsula, Ehime Prefecture.

Location	Ryoke belt: Takanawa Peninsula, Ehime Prefcture										
Filing no.	1	2	3	4	5	6	7	8	9	10	11
Sample no.	75 MY 10	75 MY 15	75 MY 14	75 MY 20	75 MY 6	75 MY 21	75 MY 4	75 MY 13	75 MY 2	75 MY 5	75 MY 1
SiO_2	47.59	53.67	63.14	66.63	67.13	68.59	71.99	75.06	75.42	76.63	77.94
TiO_2	0.32	1.23	0.22	0.59	0.64	0.47	0.26	0.09	0.20	0.09	0.07
Al_2O_3	19.83	16.37	18.41	15.65	15.54	14.14	14.03	12.86	13.01	12.75	12.56
Fe_2O_3(T)	6.36	8.97	2.52	4.56	4.74	3.80	2.67	1.24	1.94	1.19	0.77
MnO	0.12	0.16	0.08	0.08	0.08	0.08	0.06	0.03	0.06	0.02	0.03
MgO	8.39	4.49	0.17	1.23	1.28	1.04	0.45	0.13	0.35	0.08	0.10
CaO	14.30	8.61	3.26	4.05	4.52	3.38	2.01	1.24	1.62	0.75	0.94
Na_2O	0.96	2.09	3.75	3.11	3.22	3.33	3.08	2.96	3.29	3.01	2.87
K_2O	0.23	1.43	8.07	3.11	2.51	2.97	3.98	4.81	4.45	4.85	5.50
P_2O_5	0.05	0.17	0.05	0.16	0.14	0.14	0.06	0.03	0.07	< 0.01	0.03
S	0.15	0.04	0.02	0.02	0.02	0.02	0.01	0.05	0.01	0.01	0.01
LOI	1.20	1.46	0.28	0.76	0.73	0.87	0.94	0.63	0.50	0.72	0.18
Total	99.35	98.66	99.96	99.94	100.50	98.81	99.53	99.08	100.90	100.10	101.00
Rb	<10	40	220	90	100	130	140	180	170	160	130
Sr	321	287	649	254	276	207	149	90	112	67	53
Ba	37	222	951	651	555	485	613	355	268	727	126
Zr	18	128	172	170	151	135	112	81	93	111	70
Hf	0.3	2.6	4	3.8	2.8	2.6	2.8	2.6	2.5	2.9	2.6
Ta	<0.3	<0.3	<0.3	1.3	<0.3	1.2	1.4	1.3	1.2	0.9	<0.3
Y	6	26	24	38	19	24	23	28	18	16	10
V	157	132	7	48	50	38	16	7	13	<5	<5
Cr	454	109	<0.5	12.6	11.2	6.8	1.4	<0.5	2.7	<0.5	<0.5
Co	35.3	25	2.8	8.4	8.2	6.7	4	<0.1	2.3	<0.1	1.4
Ni	55	23	4	11	5	9	1	3	2	2	1
Cu	58	23	5	3	3	3	4	27	2	2	1
Zn	34	82	62	69	71	53	56	41	45	38	15
Pb	<5	8	25	15	11	7	20	35	23	22	39
As	6	<1	<1	2	<1	<1	<1	19	<1	<1	<1
Mo	<2	<2	2	<2	<2	<2	3	12	<2	<2	<2
W	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sb	0.2	0.2	<0.1	0.2	<0.1	0.2	<0.1	0.3	0.2	0.3	0.1
Cs	1.2	2.8	2.7	3.1	3.2	4.7	5	3.4	8.6	4.1	3
Th	0.5	5.4	16.6	15.6	11.5	14.1	20.7	19.1	17.5	19.1	31.9
U	<0.1	0.8	2.2	3.1	1.8	3.2	4.5	4.7	6	2.9	7
Be	<1	1	2	2	2	2	2	2	2	2	1
Sc	35.4	33.7	6.32	11.9	9.47	9.28	7.36	2.66	3.48	4.21	1.46
La	2.72	18.6	49.3	39.4	33.5	31	36	25.8	20	22.4	13.3
Ce	6	40	89	74	59	55	64	48	39	31	27
Nd	<1	26	47	32	29	25	27	24	18	21	14
Sm	0.97	5.28	7.94	6.97	4.87	4.63	5.06	4.75	3.39	3.99	2.55
Eu	0.43	1.01	1.15	1.09	1.06	0.87	0.81	0.46	0.52	0.5	0.3
Tb	<0.1	0.7	0.7	1	<0.1	0.6	<0.1	0.7	<0.1	<0.1	0.6
Yb	0.65	2.49	2.08	3.35	1.63	2.49	2.46	2.95	2.21	1.88	1.31
Lu	0.09	0.38	0.32	0.5	0.27	0.38	0.41	0.48	0.39	0.31	0.21
A/CNK	0.71	0.79	0.88	0.99	0.96	0.95	1.08	1.04	0.99	1.10	1.01
ZrT(°C)	545	707	752	778	765	759	760	734	739	766	721

Table 2 Chemical compositions of plutonic rocks of the Sanyo belt: Hiroshima city south, Hiroshima Prefecture.

Location	Sanyo belt: Hiroshima city south, Hiroshima Prefecture										
Filing no.	12	13	14	15	16	17	18	19	20	21	22
Sample no.	OSM1	76H 156	76H 153	76H 152	410072	410074	76H 151	76H 161	76H 158	73H77	73H98
SiO_2	74.13	73.06	76.58	72.58	73.66	76.70	76.68	71.18	75.35	73.68	75.35
TiO_2	0.19	0.20	0.08	0.25	0.20	0.03	0.02	0.29	0.10	0.21	0.12
Al_2O_3	13.18	13.27	12.68	14.03	13.58	12.06	12.36	13.93	12.96	12.94	12.38
Fe_2O_3(T)	2.18	2.29	1.36	2.76	2.12	0.85	1.00	2.93	1.59	2.20	1.45
MnO	0.05	0.05	0.03	0.07	0.06	0.03	0.04	0.07	0.05	0.06	0.04
MgO	0.22	0.27	0.06	0.50	0.37	0.02	0.03	0.58	0.15	0.38	0.20
CaO	1.57	1.93	1.01	2.32	1.80	0.64	0.26	2.40	1.12	1.65	1.07
Na_2O	3.02	3.30	3.28	3.57	3.16	3.30	4.11	3.46	3.24	3.31	3.18
K_2O	4.52	3.76	4.44	3.47	4.26	4.66	4.25	3.06	4.45	4.12	4.64
P_2O_5	0.05	0.05	0.02	0.07	0.06	0.01	0.02	0.07	0.02	0.05	0.02
S	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01
LOI	0.67	0.20	-0.06	0.48	0.26	0.20	0.64	0.46	0.28	0.59	0.49
Total	99.77	98.40	99.47	100.10	99.52	98.52	99.42	98.44	99.32	99.19	98.94
Rb	190	160	120	140	160	210	180	90	200	140	170
Sr	109	127	124	146	119	15	22	193	69	112	63
Ba	472	610	2346	423	506	38	50	718	349	478	402
Zr	124	111	88	156	102	63	65	125	86	115	85
Hf	5.1	4.6	3.2	4.1	2.6	4	3.7	5.1	3.5	3.5	3.1
Ta	1.6	1.5	<0.3	1.2	<0.3	<0.3	2	<0.3	1.3	1.4	1.2
Y	39	43	20	31	22	24	60	21	40	19	24
V	10	11	<5	23	16	<5	<5	28	7	17	9
Cr	<0.5	<0.5	1	3.3	7.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Co	12.1	1.8	1.4	3.9	12.3	9.3	1.5	5	2.2	2.8	2.1
Ni	3	3	1	2	3	2	1	2	1	2	2
Cu	3	1	<1	1	<1	<1	2	9	1	<1	<1
Zn	58	51	21	54	37	16	15	48	40	45	23
Pb	24	20	15	17	21	35	11	16	23	19	24
As	1	<1	<1	<1	<1	<1	2	<1	<1	<1	<1
Mo	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
W	71	<1	<1	<1	56	64	1	<1	<1	1	<1
Sb	0.5	0.1	0.2	0.1	0.3	< 0.1	0.4	< 0.1	0.1	0.4	0.3
Cs	10.2	4.1	2.4	5.4	6.7	6.5	1.9	3.2	5	1.9	3.5
Th	16.9	18.1	14.4	16.8	15	17.5	24.1	11.3	16.8	24.1	20.7
U	5.4	4.6	2.7	4.3	4.2	4	6	2	3.9	6	6.5
Be	2	2	1	3	2	3	6	2	2	6	2
Sc	6.62	6.18	2.91	6.05	3.74	1.43	2.45	7.1	2.41	2.45	2.01
La	30.8	38.5	36.8	28.4	25.8	13.5	11	33.8	23.5	11	21.3
Ce	58	66	57	48	48	28	18	59	43	18	34
Nd	33	33	27	21	25	11	14	25	22	14	16
Sm	5.67	6.57	4.72	4.74	3.39	2.9	4.94	4.06	4.31	4.94	3.02
Eu	0.66	0.72	0.88	0.69	0.57	< 0.05	0.12	0.94	0.42	0.12	0,34
Tb	<0.1	0.9	0.5	0.6	0.8	1	1	<0.1	0.6	1	<0.1
Yb	3.34	4.66	2.37	3.8	2.65	3.3	6.63	2.25	4.31	6.63	2.95
Lu	0.57	0.66	0.36	0.58	0.41	0.57	1.02	0.4	0.65	1.02	0.47
A/CNK	1.04	1.02	1.05	1.01	1.04	1.04	1.04	1.04	1.06	1.04	1.01
ZrT(˚C)	743	755	742	781	750	716	742	765	741	719	736

High values of W and Co on the 16 an 17 samples are due to crushing device.

Table 3 Chemical compositions of plutonic rocks of the Sanyo belt: Hiroshima city north, Hiroshima Prefecture.

Location	Sanyo belt: Hiroshima city north, Hiroshima Prefecture									
Filing no.	23	24	25	26	27	28	29	30	31	32
Sample no.	73H 72	73H 89	73H 93	73H 86	73H67	73H 68	73H 83A	73H 83B	73H 88	73H 82
SiO_2	52.39	61.32	73.16	73.74	75.39	75.09	75.80	77.53	72.91	77.32
TiO_2	1.28	0.72	0.22	0.19	0.12	0.12	0.06	0.06	0.18	0.04
Al_2O_3	18.56	15.45	13.54	14.24	13.30	13.78	12.32	12.66	14.10	12.23
Fe_2O_3(T)	10.90	6.30	2.45	2.24	1.82	1.61	1.13	1.11	2.03	1.02
MnO	0.19	0.11	0.07	0.07	0.06	0.06	0.05	0.05	0.07	0.04
MgO	3.76	3.03	0.46	0.34	0.23	0.21	0.10	0.09	0.37	0.05
CaO	8.86	6.34	2.13	1.91	1.36	1.42	0.83	0.82	1.66	0.57
Na_2O	2.93	3.12	3.50	3.68	3.43	3.68	3.22	3.35	3.45	3.27
K_2O	0.70	1.64	3.67	3.35	4.13	4.35	4.46	4.65	3.70	4.78
P_2O_5	0.33	0.17	0.07	0.06	0.04	0.02	0.04	0.02	0.03	0.02
S	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.00
LOI	0.31	1.09	0.32	0.66	0.68	0.28	0.30	0.34	0.71	0.18
Total	100.20	99.28	99.59	100.50	100.60	100.60	98.29	100.69	99.21	99.52
Rb	20	50	130	100	110	140	180	140	150	200
Sr	437	391	146	191	114	121	51	69	162	23
Ba	212	381	417	587	560	582	260	545	635	94
Zr	68	150	99	95	90	106	73	85	126	78
Hf	1.7	3.2	3.3	4.2	3	4	3.8	3.3	5.1	3.9
Ta	0.7	<0.3	0.8	<0.3	<0.3	<0.3	1.6	1.3	1.1	<0.3
Y	19	17	26	22	20	21	25	16	27	28
V	196	138	21	13	11	10	5	9	19	<5
Cr	9.7	26.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5.9	<0.5
Co	23.3	15.8	4	3.2	2.3	3	1.8	1.8	4.1	<0.1
Ni	6	17	2	2	2	2	<1	2	<1	2
Cu	12	22	<1	2	4	3	<1	2	<1	<1
Zn	109	75	45	39	38	28	21	18	41	17
Pb	< 5	8	17	13	16	17	21	11	13	24
As	<1	<1	<1	<1	<1	1	<1	<1	2	<1
Mo	<2	<2	<2	<2	<2	<2	<2	5	<2	<2
W	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sb	0.2	<0.1	0.3	<0.1	0.2	<0.1	<0.1	<0.1	0.2	<0.1
Cs	1	1.6	4.2	3.3	2.9	3.4	5.4	1.9	5.2	3.6
Th	1.7	4.6	15.8	9.9	14.7	15.1	15.9	11.3	17.9	20.7
U	<0.1	0.9	5.1	2.8	3.9	3.2	3.4	3.7	4.2	4.1
Be	<1	1	2	2	2	2	2	2	2	2
Sc	26.2	17.3	4.24	4.26	2.74	2.82	2.28	3.94	5.05	2.26
La	12.3	19.7	20.3	31.3	30.1	33.7	22.9	23.5	36.6	18.8
Ce	23	34	35	58	48	57	44	39	65	33
Nd	14	19	16	33	22	30	19	17	30	22
Sm	3.69	3.79	3.54	4.04	3.76	4.11	3.49	2.66	4.98	3.89
Eu	1.17	0.89	0.53	0.76	0.49	0.56	0.33	0.42	0.77	<0.05
Tb	<0.1	0.4	0.5	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1
Yb	1.88	1.68	2.84	2.2	2.22	2.46	2.68	2.29	3.74	3.27
Lu	0.28	0.24	0.42	0.35	0.34	0.41	0.48	0.38	0.68	0.56
A/CNK	0.86	0.84	1.00	1.08	1.06	1.03	1.06	1.08	1.03	1.06
ZrT(˚C)	719	740	666	740	767	747	753	764	813	743

Table 4 Chemical compositions of plutonic rocks of the Miyoshi-Shobara cities, Hiroshima Prefecture.

Location	Miyoshi-Shobara cities, Hiroshima Prefecture								
Filing no.	33	34	35	36	37	38	39	40	41
Sample no.	74H 119	67S 15	67S 31	67S 26	67S 39	67S 21	67S 25	67S 32	67S27
SiO_2	73.37	52.12	67.73	69.10	69.44	73.12	73.13	76.86	79.33
TiO_2	0.23	1.14	0.46	0.33	0.30	0.25	0.17	0.03	0.05
Al_2O_3	14.36	17.12	15.88	14.77	15.05	14.43	14.89	12.46	11.96
Fe_2O_3(T)	2.42	9.82	4.20	3.21	2.97	2.48	1.62	0.66	0.87
MnO	0.06	0.17	0.09	0.09	0.08	0.08	0.04	0.03	0.04
MgO	0.42	4.16	1.52	2.89	0.74	0.48	0.30	0.03	0.03
CaO	1.95	7.63	4.01	4.01	2.51	1.94	2.18	0.56	0.13
Na_2O	3.72	2.94	3.44	3.44	3.84	4.12	4.09	3.70	3.47
K_2O	3.89	0.80	2.64	2.64	3.34	3.23	2.96	4.79	4.62
P_2O_5	0.05	0.24	0.09	0.09	0.10	0.07	0.05	0.01	<0.01
S	0.02	0.03	0.03	0.02	0.02	0.01	0.04	0.00	0.02
LOI	0.71	2.11	2.11	0.71	0.89	0.48	0.66	0.12	0.32
Total	99.21	98.29	102.20	100.51	98.45	99.26	100.70	99.25	100.80
Rb	130	< 10	80	100	140	100	40	300	130
Sr	150	362	278	223	242	184	230	15	18
Ba	402	145	444	566	435	568	720	35	242
Zr	89	67	100	164	117	140	87	75	81
Hf	4	2.5	2.9	4.5	4	4.9	2.7	4.4	4.7
Ta	1.4	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	2.8	<0.3
Y	24	23	15	24	21	31	15	60	40
V	17	271	87	30	35	17	15	<5	<5
Cr	<0.5	35.6	25	37.4	17.4	23.8	26.7	23.7	20.9
Co	3.3	26.7	9.2	5.3	5.4	3.3	2.2	< 0.1	1.7
Ni	2	11	13	12	6	6	9	6	7
Cu	11	51	8	2	2	1	8	4	2
Zn	40	94	47	64	35	52	31	25	37
Pb	13	< 5	6	11	9	10	10	37	21
As	<1	<1	<1	1	1	<1	<1	2	2
Mo	<2	<2	<2	<2	<2	<2	<2	<2	<2
W	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sb	<0.1	0.3	0.2	0.4	<0.1	<0.1	<0.1	0.2	0.2
Cs	3.3	4.1	2.4	5.5	3.5	2.9	1.9	4.4	3.2
Th	13.6	2.6	7.3	9.4	10.5	9.2	5.6	24.3	14.6
U	3.7	<0.1	1.7	2.6	3.2	3	1.2	6.4	4.5
Be	2	<1	1	2	2	2	2	3	2
Sc	4.83	37.5	12	7.32	5.66	7.71	3.18	2.34	2.94
La	22.2	11.1	19.3	31.9	31.7	33.4	16.7	11	13.7
Ce	43	23	35	51	49	63	25	25	32
Nd	20	17	7	25	22	41	11	7	18
Sm	3.91	4.05	2.67	4.73	3.93	5.99	2.42	4.45	4.29
Eu	0.62	1.33	0.85	0.91	0.82	1.02	0.93	0.15	< 0.05
Tb	<0.1	0.8	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1
Yb	3.13	2.49	1.65	2.23	2.31	3.92	1.5	6.75	4.52
Lu	0.51	0.42	0.26	0.34	0.41	0.69	0.24	1.02	0.73
A/CNK	1.11	0.87	1.00	1.03	1.04	1.05	1.07	1.01	1.09
ZrT(˚C)	815	673	724	673	737	784	756	775	738

Table 5 Chemical compositions of plutonic rocks of the Sanin belt: Southern Shimane Prefecture.

Location	Sanin belt: Southern Shimane Prefecture								
Filing no.	42	43	44	45	46	47	48	49	50
Sample no.	73H 51	73H 60	73H 61	73H 64	73H 63	73H 62	73H 65	73H 87	73H 66
SiO_2	70.67	70.92	71.59	75.25	75.55	75.92	76.69	76.91	77.23
TiO_2	0.41	0.49	0.38	0.12	0.19	0.16	0.13	0.16	0.16
Al_2O_3	14.74	14.82	13.68	12.78	13.13	12.28	12.60	12.72	12.82
Fe_2O_3(T)	2.99	3.00	2.45	1.52	0.95	1.17	1.63	0.99	1.03
MnO	0.07	0.09	0.07	0.04	0.03	0.02	0.04	0.04	0.03
MgO	1.13	0.68	0.62	0.13	0.31	0.22	0.18	0.18	0.21
CaO	2.80	1.97	1.66	0.94	1.40	0.76	0.94	0.90	0.67
Na_2O	3.90	4.52	4.16	3.87	3.95	3.63	3.78	3.94	3.75
K_2O	3.09	2.99	3.25	3.74	3.09	3.97	3.88	3.67	4.16
P_2O_5	0.13	0.15	0.09	0.03	0.03	0.03	0.03	0.03	0.02
S	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
LOI	0.32	0.62	0.66	0.20	0.24	0.28	0.04	0.26	0.34
Total	100.30	98.59	98.59	99.64	98.86	98.45	99.96	99.80	100.43
Rb	90	110	90	140	70	110	120	120	190
Sr	344	203	156	67	165	73	68	95	52
Ba	547	447	465	568	550	523	601	516	267
Zr	121	227	219	120	93	86	117	87	69
Hf	3.7	7.8	8.3	5.1	3.9	3.2	5.7	3.2	3.6
Ta	<0.3	1.8	<0.3	<0.3	<0.3	<0.3	1.2	1.8	1.3
Y	13	31	29	32	11	15	35	14	25
V	54	37	28	7	12	10	7	9	6
Cr	11.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	5.5
Co	6.4	4.1	3.4	2.4	2.7	1.4	1.8	2.4	1.3
Ni	7	3	10	1	2	1	1	2	2
Cu	4	6	20	2	6	13	2	4	1
Zn	39	41	48	32	16	16	36	24	22
Pb	11	9	14	12	10	11	12	18	21
As	<1	<1	<1	3	<1	<1	<1	2	<1
Mo	<2	<2	<2	<2	<2	<2	<2	<2	<2
W	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sb	<0.1	0.2	<0.1	0.2	<0.1	<0.1	0.3	0.3	0.3
Cs	3	2.3	2.9	3	0.8	1.9	3.3	2.3	4.9
Th	9.1	8.6	8.7	14.6	8.5	10.4	14.2	10.1	14.6
U	2.1	3	2.5	4	2.1	2.6	3.4	3	4.4
Be	1	2	2	2	1	2	2	2	2
Sc	6.44	8.41	6.46	8.12	3.11	3.99	8.21	3.67	2.18
La	25.3	26.4	25.6	30.9	22.3	21.9	37.2	21.6	22.8
Ce	46	53	50	62	35	40	68	37	40
Nd	17	27	24	30	16	16	33	11	16
Sm	2.97	5.35	4.9	5.85	2.03	2.52	6.11	2.44	3.33
Eu	0.76	1.31	1.01	0.74	0.48	0.3	0.79	0.42	0.31
Tb	<0.1	0.9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1
Yb	1.37	3.75	3.76	4.91	1.31	1.99	3.86	1.94	2.79
Lu	0.27	0.64	0.7	0.81	0.23	0.35	0.68	0.36	0.49
A/CNK	0.99	1.04	1.02	1.05	1.06	1.05	1.04	1.05	1.05
ZrT(˚C)	726	741	755	745	765	767	746	741	741

magnetic susceptibility in Figure 3 indicate that the Ikuridani ilmenite-series granite has validity, but the Mitsumori granite has roughly 50 % of magnetite-free values, not typical magnetite-series.

Their age is also not Paleogene but Late Cretaceous. K-Ar age on biotite of the Mitsumori Granite revealed a Late Cretaceous in age of 81.8 ± 4.1 Ma (Matsuura, 1998), and the zircon U-Pb age is slightly older but still in the Late Cretaceous age of 86.2 ± 0.7 Ma (Tani *et al*., 2014). Thus it is considered to belong to a part of Sanyo belt granitic activities in this paper.

2.3 Sanin belt granitoids

The Sanin belt granitoids of Paleogene age are classified into three groups, as (i) early, (ii) middle and (iii) late intrusive rocks in the Akana Quadrangle Series by Matsuura (1990). The main Paleogene granitoids, elongating ENE direction by a size of 8 and 29 km at ENE of the Oasa township area, are called Asuna Granites, and are divided into the marginal granophyre and the central granite porphyry by Rezanov *et al*. (1994). They give the internal isochron ages of 40.4 ± 2.9 Ma and 28.9 ± 5.8 Ma, respectively.

The age discrepancy is much larger than one can think of the cooling of the marginal to the main phases of the crystallization. The errors are also so large; thus further chronological study, especially on zircon, is definitely needed. One zircon dating in our study showed 39.8 ± 0.6 Ma at north of Akana (Tani *et al*., 2014). Besides, small dioritic bodies are associated with these biotite granites (Matsuura, 1990).

Along the Tottori-Okayama transect toward the east of our study area, the largest age gap was recognized at 40-60 Ma (Iida *et al*., 2015), which could separate the granitic activities of the Sanyo and Sanin belts.

3. Result of analyses and discussion on the north-south chemical variation

The studied rocks are listed in Appendix 1, and their chemical compositions are given from south to north in Tables 1 to 5. Chemical analyses were carried out at Activation Laboratories Ltd. (Actlabs, Toronto, Canada) using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Magnetic susceptibilities were measured using Bison 3101 Model susceptibility meter (Bison Instruments Inc., Chanhassen, Minnesota, USA).

The studied rocks are mostly monzogranite in the feldspars and quartz ratios, except for the Takanawa Peninsula in the Ryoke belt where quartz diorite-granodiorite occurs an affair amount. The granitoids are extremely low in the magnetic susceptibility, χ-values below 100 × 10^{-6} Am^2/kg, belonging to the ilmenite-series, both in the Ryoke belt and the southernmost Sanyo belt. The magnetic susceptibility increases gradually toward the north, then, sporadic magnetite-series values appearing in the ilmenite-series granitic terrane in the northern Sanyo belt (Appendix 1).

Granitoids of the Sanyo belt around the Hiroshima city north region are mostly granitic in composition (see also Takahashi, 1993), and contains locally xenolithic gabbroids including quartz dioritic rocks in the limited places, whose magnetic susceptibility goes up to 731 × 10^{-6} Am^2/kg (e.g., 73H72, Appendix 1); the values are still low as 1/5th of that of typical magnetite-series gabbroids in the Zakka magnetite-placer mine area of the Sanin belt (see, Fig. 8 of Ishihara, 1979). The surrounding granites show the values of the ilmenite-series.

Chemical components of the studied rocks with SiO_2 contents higher than 66 % (granodiorite-granitic composition), are plotted against the silica contents, and are shown from south to north in Figures 2 to 5. The most distinct character is seen in the alkali ratio. Na_2O contents, for example, are least in those of the Ryoke belt and increase gradually toward north, then the highest in those of the Sanin belt (Fig. 2C). On the contrary, K_2O contents are highest in those of the Ryoke belt and are least in those of the Sanin belt (Fig. 2D). Na_2O-rich character was also observed in granitoids of the Shirakawa region of the Chubu District (Ishihara and Tani, 2004), which is an eastern extension area of the Sanin belt.

Na_2O is the main constituent of plagioclase, and also contained in some amounts of the K-feldspar in igneous rocks. Therefore, Na_2O-rich magma must have originated in igneous source rocks containing plagioclase, while K_2O-rich granitoids of the Ryoke belt should be affected by sedimentary source rocks of mainly pelitic in composition. In the Japanese eugeosynclinal sediments, the pelitic rocks are generally $K_2O > Na_2O$ but psammitic rocks are $Na_2O > K_2O$ (Ishihara *et al*., 1985). Contribution of the sedimentary rocks on the granitoids of the Ryoke and southern Sanyo belts were proved by relatively high oxygen-isotopic ratios on the mineral and whole rock values on these granitoids (Honma and Sakai, 1976; Ishihara and Matsuhisa, 2001).

Among mafic components, MgO and TiO_2 are enriched in the granitoids of the Sanin belt (Fig. 2A and Fig. 3B), reflecting Mg-rich compositions of the mafic silicates (Czamanske *et al*., 1981) and abundant titanite occurring as accessary mineral (e.g., 0.9 vol.% in the Kawai mingling rock, Ishihara, 1971), yet no distinct difference observed on the total iron as Fe_2O_3 (Fig. 3C) and MnO (Fig. 3D). Minor element of Zn (Fig. 5B) is associated with these mafic rock-forming minerals, yet not reflecting on the regional zonal variations.

Both Rb (Fig. 4A) and Pb (Fig. 5A) contents increase with increasing SiO_2 content, because the silica contents are positively correlated with the K_2O contents, and Rb and Pb tend to replace

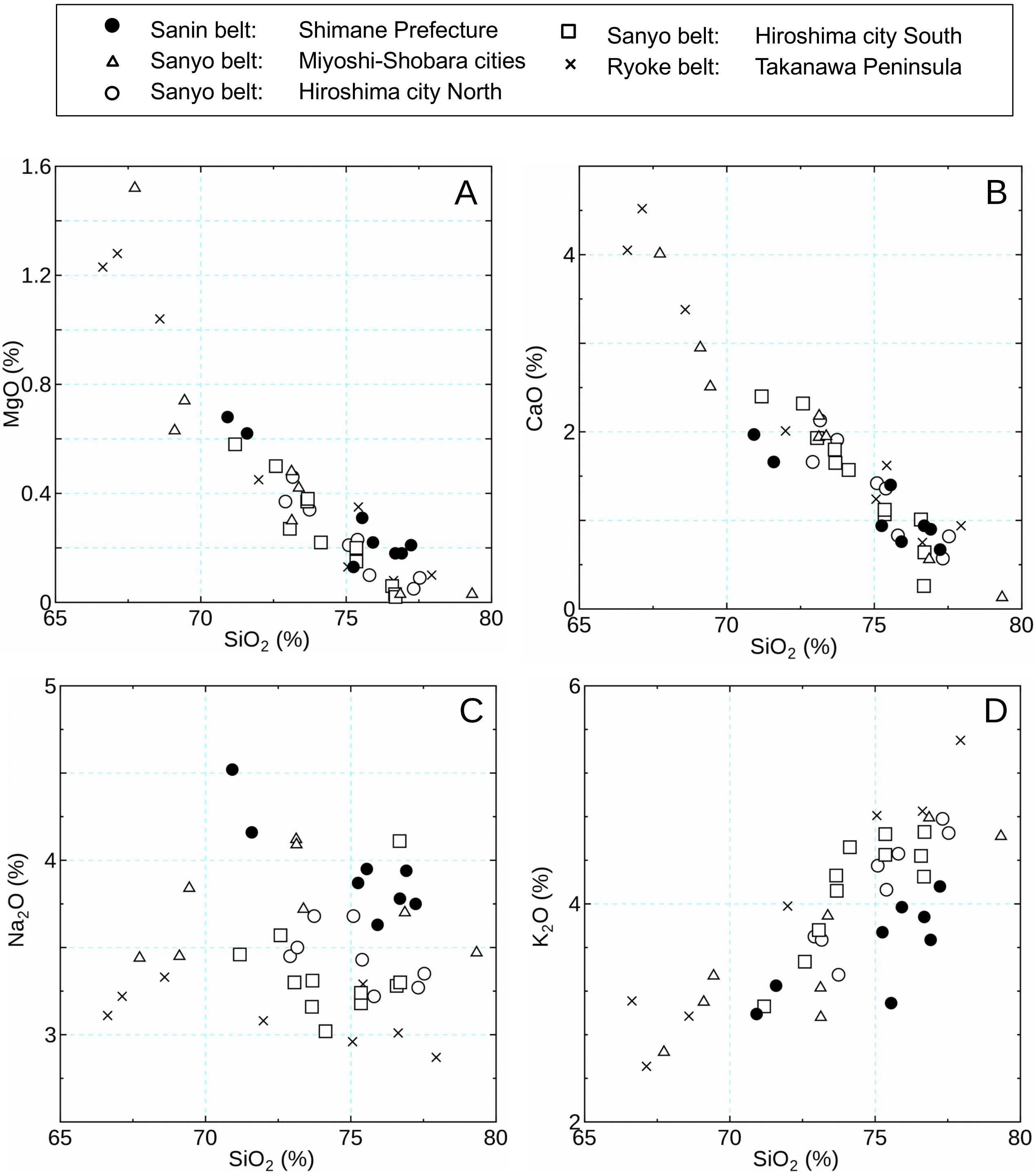

Fig. 2 Contents of MgO, CaO, Na_2O and K_2O plotted against SiO_2 of the granitoids along the Hiroshima city transect.

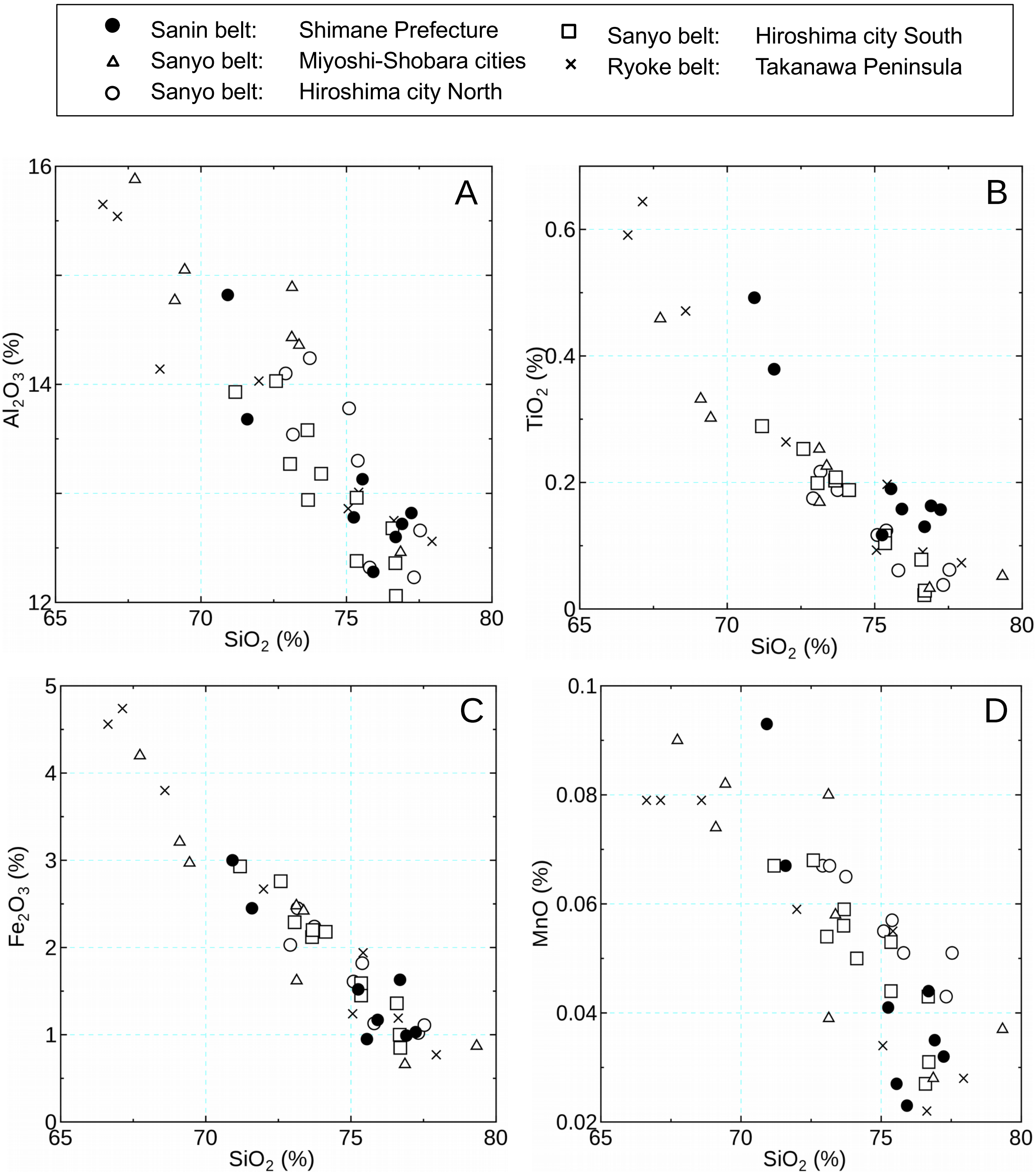

Fig. 3 Contents of Al_2O_3, TiO_2, Fe_2O_3 and MnO plotted against SiO_2 of the granitoids along the Hiroshima city transect.

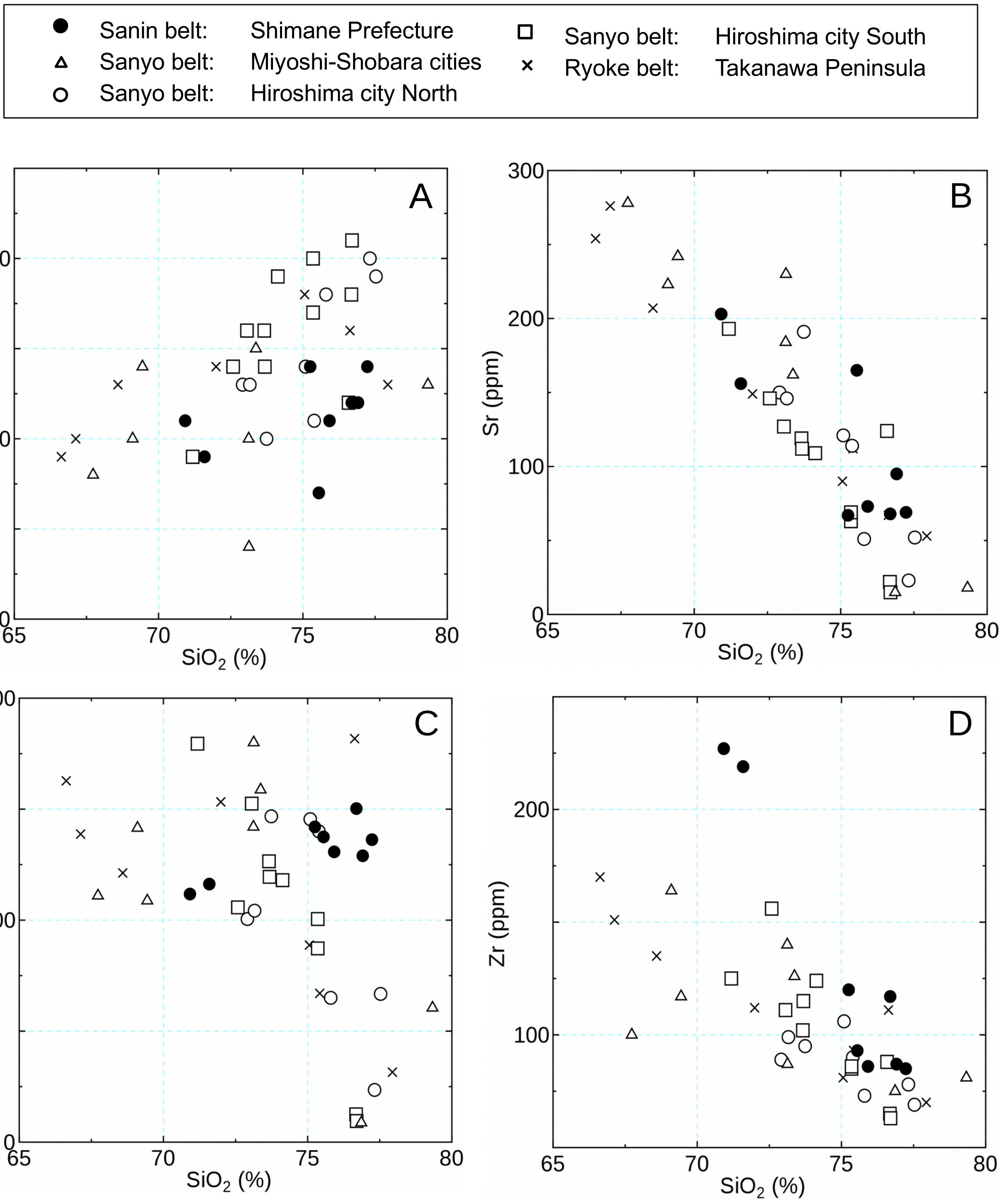

Fig. 4 Contents of Rb, Sr, Ba and Zr plotted against SiO_2 of the granitoids along the Hiroshima city transect.

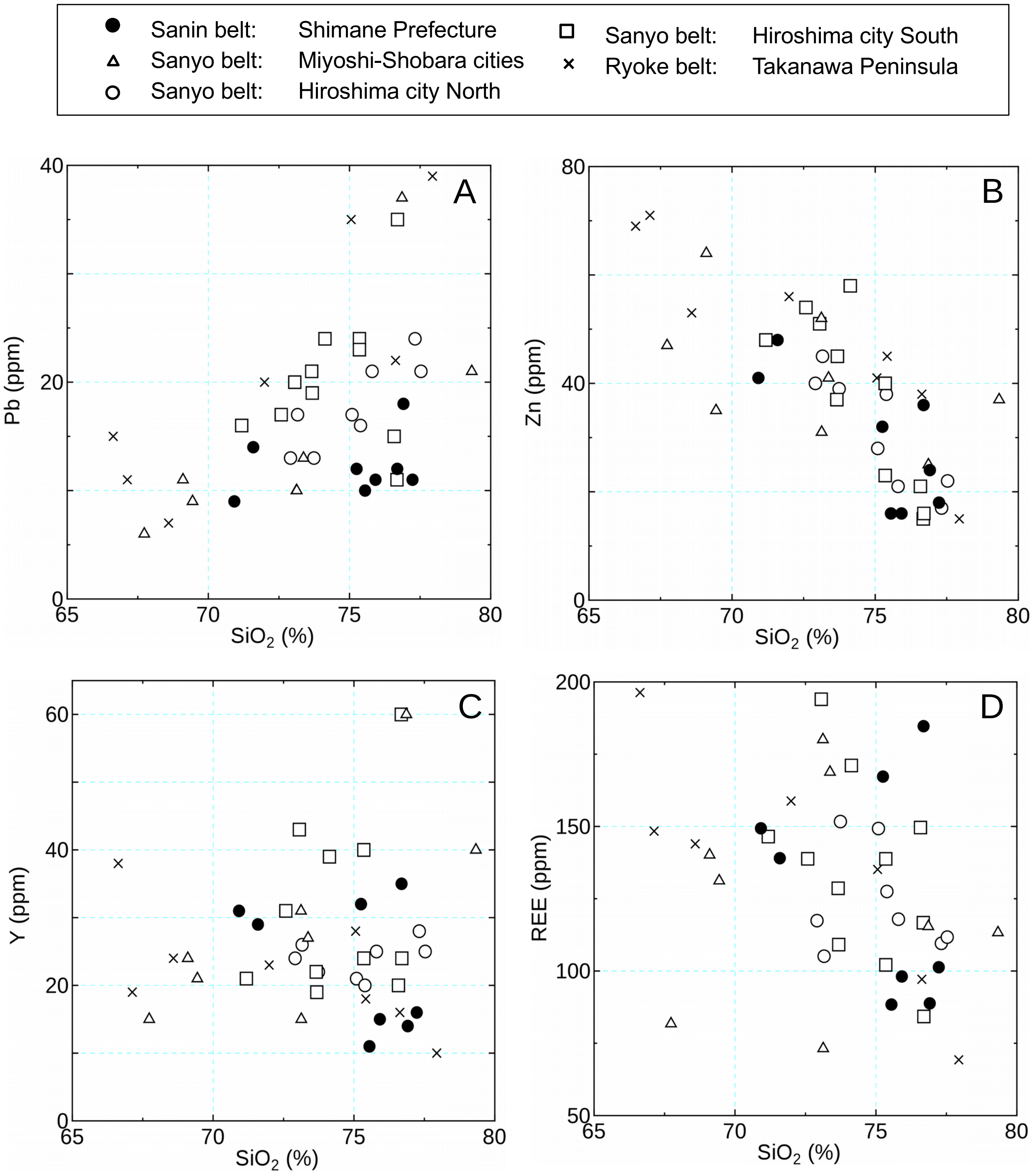

Fig. 5 Contents of Pb, Zn, Y and REE plotted against SiO_2 of the granitoids along the Hiroshima city transect.

K-position of the K-feldspar. However, the amounts are different in each zone, being low in the Sanin belt, but high in the Ryoke belt and the Sanyo belt of Hiroshima south. Enrichment of Rb and Pb in the granitoids of the Sanyo belt right next to the Ryoke belt has also been recognized at the Chubu transect, which are due to degree of magmatic fractionation (Ishihara and Terashima, 1977).

Sr contents are generally lower than 300 ppm in the studied granitoids and go down to 15 ppm. The contents are positively correlated with CaO contents. Y contents range generally from 40 to 15 ppm in the granodiorite and granite compositions, giving rise to low Sr/Y ratio of <1 to 27 in the studied granitoids (Tables 1 to 5), which are non-adakitic character. However, adakitic rocks were reported toward the east and the west, such as the Kinki district of the Sanyo belt (e.g., Tamba Granitoids; Kiji *et al*., 2000) and Ryoke belt (Katsuragi Granitoids; Nishioka, 2008), also in the northern part of the Kyushu District (Izawa *et al*., 1990; Yada and Owada, 2003; Kamei, 2004). Ba may have the same trend as the Sr plotted, but the figure is somewhat erratic (Fig. 4C).

Zr contents are high in the granitoids of the Sanin belt (Fig. 4D). Zircon saturation temperatures of Watson and Harrison (1983), listed in Tables 1 to 5, however, are highest in the Ryoke zone (753 ºC, n=9) because granodiorite is much abundant here. Granitic rocks in the other zones, all in monzogranitic composition, have the average temperatures of 741-749 ºC as follows :

Sanin belt : 747 ºC (n=9)
Sanyo belt : Miyoshi-Shobara : 741 ºC (n=7)
Sanyo belt : Hiroshima north : 749 ºC (n=8)
Sanyo belt : Hiroshima south : 745 ºC (n=11)
Ryoke belt : Takanawa Peninsula : 753 ºC (n=9), 744 ºC (n=5, granite only)

Alumina saturation index (A/CNK) was calculated and listed in Tables 1 to 5. It is above 1.0 in the monzogranitic composition, i.e., defined as peraluminous, but never exceeds 1.1, which is the value necessary to define as S-type granitoids. Thus, all the plutonic rocks studied belong to I type.

4. Concluding remarks

The late Cretaceous-Paleogene granitoids were studied to examine the N-S geochemical variations across the city of Hiroshima. The studied granitoids are most felsic part among the Japanese granitic terranes, being mostly monzogranitic, although the Ryoke granitoids are composed of both granodiorite and monzogranite. The magnetic susceptibility is the least in the Ryoke belt, and increases northwards, but typical magnetite-series values appear in those of the Sanin belt, implying the oxygen fugacity of the granitic magmas increased northwards.

The initial Sr ratios decrease from 0.7082 of the Ryoke belt to 0.7050 of the Sanin belt (Shibata and Ishihara, 1979). The whole-rock oxygen isotopic ratios also decrease from 10.3-11.3 ‰ on the Takanawa Peninsula, northward to 6-8 ‰ in the Daito-Minari area of the Sanin District (Ishihara and Matsuhisa, 2001). These observations indicate that older sedimentary and igneous rocks contained in the source rocks of the granitic magmas in the Ryoke and Sanyo belts, while only igneous source rocks were involved in those of the Sanin belt.

Among major chemistry, the Na_2O contents are clearly high in the Sanin belt, and K_2O contents tend to be enriched in the Ryoke belt. The Na_2O/K_2O ratio, therefore, increases northwards that reflect the difference in the source rocks. High Sr granitoids and adakitic rocks (Martin *et al*., 2005; Moyen, 2009) were not found in the studied region, but reported in the northern Kyushu granitic region, and in the Kinki District of the Sanyo and Ryoke granitic belts (Kiji *et al*., 2000; Nishioka, 2008), which have been located toward west and east of our studied region.

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Appendix 1 Locality and magnetic susceptibility of the analyzed specimens.

Filing & Sample nos.	**Locality**	**Rock name**	**χ value (10^{-6} Am^2 /kg)**
	Ryoke belt: Takanawa Peninsula, Ehime Prefecture		
I. 75MY10	Imabari-shi, Namikata-cho, Mategata	Fine-grained gabbroid	χ=30
2. 75MY15	ditto, Daikaku-bana	Medium diorite	χ=19
3. 75MY14	ditto, Morigami	Very coarse syenite	χ=12
4. 75MY20	Matsuyama-shi, Kikuma-cho, Shimojo-Ogawa	Very coarse granodiorite, foliated	χ=15
5. 75MY6	ditto, Tanojiri-Iwadouji coast	Very coarse granodiorite, foliated	χ=16
6. 75MY21	Ochi-gun, Tamakawa-cho, Shimokiji	Very coarse granodiorite, foliated	χ=18
7. 75MY4	Matsuyama-shi, Takahama coast	Medium, bt granite	χ=19
8. 75MY13	Imabari-shi, Namikata-cho, Shiraiwa pegmatite mine	Medium, bt granite	χ=20
9. 75MY2	Matsuyama-shi east, Shukunono	Coarse, bt granite	χ=14
10. 75MY5	Matsuyama-shi, Hojyo, coast at Kuriizaka	Aplitic granite	χ=15
11. 75MY1	Matsuyama-shi far east, Fujinono	Fine, bt leucogranite	χ=13
	Sanyo belt: Hiroshima city south, Hiroshima Prefecture		
12. OSM01	Kure-shi, Kurahashi-jima, Osame	Medium bt granite	χ=18
13. 76H156	Kure shi, Hiro-machi	Coarse, hb-bt granite	χ=20
14. 76H153	Kure Line, Koyaura station	Ditto, pink Kf granite	χ=96
15. 76H152	Kure Line, 2.3 km to Saka station	Very coarse, hb-bt granite	χ=22
16. 410072	Aki-gun, Fuchu-cho, road to Mt. Gosaso	Fine bt granite, pink Kf	χ=57
17. 410074	Aki-gun, Fuchu-cho, road to Mt. Gosaso	Fine bt granite, very fresh	χ=24
18. 76H151	Hiroshima-shi, Iwahana, old quarry	Fine aplitic granite	χ=19
19. 76H161	Higashi Hiroshima-shi, Shiwa-higashi	Coarse hb-bt granite	χ=99
20. 76H158	Higashi Hiroshima-shi, Akitsu tunnel	Very coarse bt granite	χ=58
21. 73H77	Hiroshima-shi, Saiki-ku, Itsukaichi-cho, Jiro-Goro-taki, 1 km from electric power stn.	Fine, pink Kf granite	χ=18
22. 73H98	Hiroshima-shi, Saiki-ku, Saiki-cho, Sakai-Sekizai	Fine bt granite	χ=77
	Sanyo belt: Hiroshima city north, Hiroshima Prefecture		
23. 73H72	Yamagata-gun, Kitahiroshima-cho, Kokitsugi	Fine ol-px gabbro	χ=731
24. 73H89	ditto. Honji-Urihara, Nakano-Sekizai	Medium diorite, "Aomikage"	χ=489
25. 73H93	Hiroshima-shi, Asakita-ku, Kabe-cho, Nabara-dum waste	Coarse hb-bt granite	χ=75
26. 73H86	Yamagata-gun, Kitahiroshima-cho, Oasa, Ikadatsu	Medium aplitic granite	χ=132
27. 73H67	ditto, Kitahiroshima-cho, Kawato	Fine bt granite, marginal phase	χ=25
28. 73H68	ditto, Kitahiroshima-cho, Choja	Coarse bt granite	χ=93
29. 73H83A	ditto, ditto, Oasa, Yokogawa	Medium bt granite	χ=140
30. 73H83B	The same locality as 73H83A	Fine aplitic granite	χ=85
31. 73H88	Yamagata-gun, Kitahiroshima-cho, Oasa, Kami Narutaki	Fine bt granite	χ=71
32. 73H82	ditto, ditto, Toyohira, Shirohara	Aplitic granite	χ=137
	Sanyo belt: Miyoshi-Shobara cities, Hiroshima Prefecture		
33. 74H119	Miyoshi-shi, Sakugi-cho, Karako	Hb-bearing bt granite	χ=160
34. 67S15	Shobara-shi, Kuchiwa-cho, Miyauchi	Fine px-hb qz gabbro	χ=1,166
35. 67S31	ditto, Kimita-cho, Terahara	Medium hb-bt granodiorite	χ=792
36. 67S26	ditto, Kimita-cho, Morihara	Fine granite porphyry	χ=69
37. 67S39	ditto, Funo-cho, Nakamura	Medium hb-bt granodiorite	χ=387
38. 67S21	ditto, Kuchiwa-cho, 700 m W of Yoshiki	Medium hb-bt granodiorite	χ=283
39. 67S25	ditto, Kuchiwa-cho, Ashihara	Medium hb-bt granodiorite	χ=17
40. 67S32	ditto, Kimita-cho, Nakanohara	Fine, bt granite	χ=19
41. 67S27	ditto, Kimita-cho, Fujikane N, Irigimi body	Fine porphyritic aplite	χ=14
	Sanin belt: Shimane Pref. and Northernmost Hiroshima Prefecture		
42. 73H51	Unnan-shi, Kakeya-cho, Nakatani	Bt-hb granodiorite	χ=698
43. 73H60	Ochi-gun, Misato-cho, Tunnel waste	Medium bt granite	χ=235
44. 73H61	Ochi-gun, Misato-cho, Oura	Medium bt granite	χ=160
45. 73H64	Ochi-gun, Onan-cho, near H63	Fine bt granite	χ=85
46. 73H63	Ochi-gun, Onan-cho, below bridge	Aplitic granite	χ=215
47. 73H62	ditto, Onan-cho, Asuna north 1.2 km	Aplitic granite	χ=362
48. 73H65	Ochi-gun, Onan-cho, Danbara	Green bt granite	χ=642
49. 73H87	Ochi-gun, Onan-cho, Kobayashi	Fine aplitic granite	χ=193
50. 73H66	Yamagata-gun, Kita-Hiroshima-cho, Oasa north	Fine porphyritic granite	χ=316

bt: biotite, hb: hornblende, Kf: alkali feldspar, ol: olivine, px: pyroxene

西南日本内帯，広島付近を横断する後期白亜紀－古第三紀花崗岩類の地球化学的性質の南北変化

石原舜三・大野哲二

要　旨

標記地域の花崗岩類分布域は南から領家帯・山陽帯・山陰帯に分けられる．領家帯では花崗岩のほか花崗閃緑岩が分布するが，山陽帯と山陰帯では少量の斑れい岩–閃緑岩を伴うものの主体は花崗岩である．全岩帯磁率は山陰帯で最も高く，南方に低くチタン鉄鉱系の値となり，領家帯で最少となる．ジルコンU-Pb年代は，領家帯が最も古く97.8～95.3 Ma，山陽帯が92.3～85.6 Ma，山陰帯が39.8～33.5 Maである．化学組成上はNa_2O/K_2Oが山陰帯の花崗岩類で最も大きく，領家帯の岩石で最も小さい．これは火成岩起源で同比が大きく堆積岩起源で同比が小さい起源物質の性質を反映しているものと思われる．アルミナ飽和指数は1.0は超えるが，1.1を超えるSタイプは存在しない．カリ長石のKを置換するRbとPbは山陰帯で最も乏しく，領家帯とその北縁の山陽帯で富んでいる．この傾向は$\delta^{18}O$の傾向と同様であって，そのマグマの生成に堆積岩地殻物質が関与したことを示している．