A Rb-Sr ISOTOPIC STUDY ON THE OJIKA AND ICHINOHE GABBROIC COMPLEXES IN THE KITAKAMI MOUNTAINS, NORTHEAST JAPAN

KAZUYA KUBO

Department of Earth Sciences, Faculty of Science, Chiba University, Chiba, Japan.

Rb and Sr concentrations and Sr isotopic compositions were analyzed for the Ojika gabbroic complex, the S-mass in the Aji islet and the Ichinohe complex in the Kitakami mountains. The initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of 0.7045~0.7050 for the former two is somewhat higher than that of 0.7041 for the latter.

For the Ichinohe complex, 105 ± 30 m.y. is obtained as the whole rock isochron age, which shows well-agreement with the biotite-whole rock isochron age of 101~110 m.y. These ages indicate the age of emplacement of the Ichinohe complex.

The low initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios for these complexes indicate that incorporation of crustal materials in the original magmas is eliminated.

The K/Rb ratios of the present district is 72~287. These values are somewhat lower than those of some other granitic rocks in Japan.

INTRODUCTION

The Mesozoic plutonic masses of the Kitakami mountains are classified into the following three types (Kubo, 1977).

Type I: granodioritic to adamellitic masses, generally having extensive exposure, such as the Tono mass, Miyako mass and Senmaya mass.

Type II: gabbroic masses with various amounts of quartz dioritic rock, such as the Ojika mass, Tenjinmori mass and Orikabe mass. The masses of this type are characterized by low K compared with the masses of Type III, though monzonitic rock is sometimes associated with them.

Type III: gabbroic masses, characterized by higher K, with various amounts of adamellitic and syenitic rocks, such as the Ichinohe mass and Himekami mass.

To elucidate the origins and mutual

relationships of these three types of the masses, the geological and petrological characters of several plutonic masses have been investigated (Kubo, 1976, 1977). In the present paper, will be reported the Sr isotopic ratios of the Ojika mass and its satellitic mass belonging to Type II, and of the Ichinohe mass belonging to Type III. With respect to the Sr isotopic features of the masses belonging to Type I, the data for the Tono and Kesengawa masses, Miyako mass and Taro mass have been reported by Shibata (1974) and Shibata *et al.* (1977), respectively.

GEOLOGICAL SETTING

The Ojika gabbroic complex is exposed at the central part of the Ojika Peninsula, intruding the Mesozoic formation of the Ojika group. It is composed of seven rock types, such as clinopyroxenite, porphyritic

clinopyroxene gabbro, olivine two pyroxene gabbro, clinopyroxene hornblende gabbro, two pyroxene gabbro, pyroxene hornblende diorite and quartz diorite, in the order of intrusion. The petrology of the complex has recently been reported by Igi *et al.* (1974) and Kubo (1977).

The S-mass is one of the satellitic masses of the Ojika gabbroic complex, being exposed at the southern coast of the Aji islet to the south of the Ojika Peninsula. It is composed of six rock types, such as granodiorite, medium-grained quartz gabbro, fine-grained quartz gabbro, quartz diorite, medium-grained monzonitic quartz diorite and fine-grained monzonitic quartz diorite. The petrography of the mass has been reported by Kubo (1976).

The Ichinohe complex is outcropping in the Paleozoic formation at Ichinohe, near the northern end of Iwate Prefecture. It is composed of three masses such as olivine bitotite clinopyroxene alkali gabbro group, biotite hornblende alkali gabbro group and quartz syenite group. Petrology of this complex has been reported by Onuki and Tiba (1964).

ANALYTICAL PROCEDURES

Whole rock samples used in the present study were prepared from 1~3 kg rock specimens. Biotite separation was carried out tapping the rock-powder within a glass-beaker.

Rb and Sr concentrations were determined by isotope dilution method using ^{87}Sr and ^{84}Sr spikes.

Isotope analyses were made on the JEOL-05 RB mass spectrometer with a 90° -30 cm radius analyzer. Triple filaments were used and samples were loaded on the side filaments as Rb_2SO_4 or $\text{Sr}(\text{NO}_3)_2$.

Ion currents were detected with an electron multiplier, output of which was amplified by a vibrating reed electrometer, recorded on a digital voltmeter and punched on paper tape.

All $^{87}\text{Sr}/^{86}\text{Sr}$ ratios analyzed were normalized to $^{87}\text{Sr}/^{86}\text{Sr}=0.1194$ and adjusted $^{87}\text{Sr}/^{86}\text{Sr}=0.7080$ for Eimer and Amend Sr standard.

$^{87}\text{Sr}/^{86}\text{Sr}$ ratios listed in Table 1 are mean values of 20~30 peak sets, of which twice of the standard deviation is $0.0006\sim 0.0012$.

The analytical uncertainty in Rb and Sr concentrations is considered to be less than 3%. For several samples, Rb and Sr concentrations were determined by X-ray fluorescence analysis or γ -ray spectrometry analysis, so that the uncertainty for the concentrations is somewhat larger, being however less than 10%. ^{87}Rb decay constant used is $1.39\times 10^{-11}/\text{y}$.

RESULTS AND DISCUSSION

All the Rb-Sr data analyzed are listed in Table 1 and the whole rock data are displayed in $^{87}\text{Sr}/^{86}\text{Sr}$ - $^{87}\text{Rb}/^{86}\text{Sr}$ isochron diagram in Figure 1.

The Ojika gabbroic complex

Six samples taken from the main rock types were analyzed. Rb content of each rock type is low, reflecting the character poor in K content. $^{87}\text{Rb}/^{86}\text{Sr}$ ratios are not so different that meaningful isochron is not defined. The K-Ar age of biotite+hornblende in quartz diorite of the complex was determined by Kawano and Ueda (1964), giving 120 m.y. Supposing that this age being that of the emplacement of the complex, initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of the complex is considered to be $0.7045\sim 0.7050$.

Table 1. Analytical data.

No.	Sp.No.	K (%)	Rb (ppm)	Sr (ppm)	K / Rb	⁸⁷ Rb / ⁸⁶ Sr	⁸⁷ Sr / ⁸⁶ Sr
1	74041901	0.12	6*	495*	200	0.037*	0.70488
2	74121607	0.07	7.8	560.0	90	0.0402	0.70406
3	73072309	0.07	tr.	552*			0.70431
4	73072608	0.24	12.9	513.6	186	0.0729	0.70528
5	75110301	0.17	22.0	602.0	77	0.1058	0.70506
6	533	0.76	21*	479*	362	0.126*	0.70483
7	74061703	0.64	23**	631**	278	0.106**	0.70477
8	74012913	1.05	56**	593**	188	0.273**	0.70514
9	74012910	2.00	97**	625**	206	0.449**	0.70529
10	74012911	1.55	86**	510**	180	0.488**	0.70529
11	K 334	1.73	71*	419*	244	0.489*	0.70496
12	K 335	4.31	182*	764*	237	0.689*	0.70513
13	K 337	0.34	46.7	87.7	73	1.5486	0.70634
14	75111001	2.74	107.6	1333.5	255	0.2337	0.70432
15	75111101	3.55	123.9	960.9	287	0.3735	0.70472
Biotite B-75111001			415.8	22.3		53.8947	0.78574

No. 1~6: The Ojika gabbroic complex.

1: Porphyritic clinopyroxene gabbro. 2: Olivine two pyroxene gabbro. 3: Two pyroxene gabbro. 4: Pyroxene hornblende diorite. 5: Quartz diorite. 6: Porphyritic clinopyroxene gabbro intruded by quartz diorite.

No. 7~10: The S-mass.

7: Medium-grained quartz gabbro. 8: Quartz diorite. 9: Medium-grained monzonitic quartz diorite. 10: Fine-grained monzonitic quartz diorite.

No. 11~15: The Ichinohe complex.

11: Alkali gabbro. 12: Quartz syenite. 13: Olivine clinopyroxenite. 14: Alkali gabbro. 15: Hornblende alkali gabbro.

Biotite: separated from the rock sample No. 14.

* X-ray fluorescence analysis. **γ-ray spectrometry analysis.

The S-mass

Four samples from the main rock types were analyzed. Rb content of each rock type is somewhat higher than those in the Ojika gabbroic complex, though the variation of ⁸⁷Rb/⁸⁶Sr ratio is not so much as defining the isochron. The differentiation of the S-mass is mainly controlled by the mechanical behavior of crystals in the melt during emplacement (Kubo, 1976), and calcic plagioclase as well as K-feldspar is enriched in the derivatives at later stage of differentia-

tion. This may be the reason why Rb/Sr ratio is not so high in spite of relatively higher content of K-feldspar.

The Rb-Sr isotopic data mentioned above are in accordance with the idea that the S-mass and Ojika gabbroic complex were derived from a common original magma, assuming that both masses were emplaced in almost same age.

The Ichinohe complex

Five whole-rock samples and one biotite

Fig. 1. Whole rock isochron diagram.

1: The Ojika gabbroic complex. 2: The S-mass. 3: The Ichinohe complex.

sample were analyzed. The data for whole-rock samples define an isochron of 105 ± 30 m.y. with an initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.7041 ± 0.0002 . And also, the age calculated from the biotite-whole rock isochron is $101 \sim 110$ m.y. These ages are in agreement with the K-Ar ages of $106 \sim 116$ m.y. for microcline and biotite determined by Kawano and Ueda (1964). Therefore, these ages are considered to indicate the age of the emplacement of Ichinohe complex. In this case, the consolidation of the complex after emplacement must have proceeded rapidly.

Onuki and Tiba (1964) considered that the Ichinohe complex was formed by successive intrusion of magmas derived and uprison from a common magma reservoir at certain deeper level. If it was the case, the above data indicate that all the processes, the differentiation of magma at depth and the emplacement and consolida-

tion of the complex, proceeded in a relatively short span of time.

Initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios

The initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of the Ojika gabbroic complex and S-mass are somewhat higher than that of the Ichinohe complex, though the difference is smaller than 0.001. If this difference is meaningful, it would be ascribed to the slight difference of the source materials from which both complexes were derived. Because it is difficult to derive the both magma types from a common source, one being more enriched in Rb and lower in $^{87}\text{Sr}/^{86}\text{Sr}$ ratio and the other being poorer in Rb and higher in $^{87}\text{Sr}/^{86}\text{Sr}$ ratio.

It may be admitted, however, another possibility exists for the genetical relation of both types of magma. Namely, the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio may be a function of the duration from the time of formation of

original (undifferentiated) magma to the time of differentiation into magmas representing each rock type. Therefore, if the above duration is somewhat longer for the case of the Ojika gabbroic complex than that of the Ichinohe complex, both complexes could be interpreted as the derivatives from a common source.

Some of the plutonic masses belonging to Type I have been isotopically analyzed. The Tono and Kesengawa granites reported by Shibata (1974) have the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.7043 ± 0.0004 . The Miyako and Taro granites were also analyzed (Shibata *et al.*, 1977), the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of the former being 0.70378 ± 0.00015 .

Thus, it may be concluded that the three types of plutonic masses in the Kitakami mountains are fairly similar in their initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, ranging from 0.7035 to 0.7050, the possibility of incorporation of crustal materials in the original magma being eliminated.

Recently, Shuto (1974) has proposed the division of L zone and H zone of the Cenozoic acidic volcanic rocks in Japan based on their initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios, and Shuto and Kagami (1975) have shown that the zonal distribution mentioned above might be adoptable also to the Mesozoic granites. The present data are in harmony with their results.

K/Rb ratios

All the present data are plotted in K-Rb diagram (Fig. 2). They are in the Main trend of Shaw (1968), and show the K/Rb ratios ranging from 72 to 287 (except for metamorphosed rock sample). The data are also plotted in K/Rb-K diagram (Fig. 3). As shown in this diagram, the data for Ichinohe complex are plotted in the area of alkali basalts (Beswick, 1976) and those for the Ojika gabbroic complex have some-

Fig. 2. Plots of K versus Rb for the rocks, 1: Ojika gabbroic complex, 2: S-mass and 3: Ichinohe complex.

Fig. 3. Plots of K/Rb versus K. Symbols are the same as Figure 2. Th, A and U are the fields for oceanic tholeiite, alkali basalt and ultramafics, respectively (Beswick, 1976).

what wider range of variation. Systematic change of K/Rb ratios with the differentiation of each complex is not recognized.

The K/Rb ratios of granitic rocks in Japan have been reported in recent years (Ishizaka, 1971; Ishizaka & Yanagi, 1977;

Kanaya & Ishihara, 1977). The K/Rb ratios of Central Ryoke granites are ranging from 100 to 400. The ratios of Ibaragi granitic complex range from 150 to 250 and those of Tanzawa plutonic rocks range from 541 to 630. Compared with these data, the K/Rb ratios of the present district is somewhat low.

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北上山地、牡鹿及び一戸斑れい岩体の Rb-Sr 同位体による研究

久保和也

北上山地、牡鹿岩体と、その近傍の同一マグマ起源と予想される網地島 S 岩体から計 10 個、一戸岩体から 5 個の全岩試料及び後者中の黒雲母の試料 1 個の Sr 同位体を測定した。

一戸岩体の黒雲母—全岩年代 (101~110 m. y.) と全岩アイソクロン年代 (105 ± 30 m. y.) とは良い一致を示す。これらの年代は本岩体の K-Ar 年代とも一致しており、従って岩体の進入の年代を示していると考えられる。この場合、マグマの分化から進入固結までの時間は短かった。

牡鹿岩体の試料は Rb に乏しく、全岩アイソクロンをひく事ができない。しかしながら、石英閃緑岩の K-Ar 年代 (120 m. y.) を岩体の進入年代と考えると、本岩体を形成したマグマは進入時に 0.7045~0.7050 の $^{87}\text{Sr}/^{86}\text{Sr}$ 比を有していた事になる。この値は一戸岩体の値 (0.7041) に比べてわずかながら高い。この差は起源物質の違いによるものであるかも知れないが、マグマの発生から分化までの時間の差によっても説明は可能である。いずれにしてもこれらの値は、両岩体のマグマの形成に地殻物質が全んど寄与していない事を示す。

両岩体の K/Rb 比は 72~287 で、日本の他の花崗岩体の報告例と比べるとやや低い値である。