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A Rb–Sr whole rock isochron age of the Gozu Granite, Niigata Prefecture, central Japan

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Introduction

Cretaceous–Paleogene granitoid and contemporaneous volcanic rocks are widely distributed in northeast Honshu, Japan. The Tanakura Tectonic Line divides Northeast Honshu into the Northeast and Southwest tectonic zones (Fig. 1). Based mainly on petrography and radiometric ages, the granitoid rocks in the NE Japan Zone (eastern side of the Tanakura Tectonic Line) are further divided into the Kitakami and Abukuma Belts (Fig. 1). Granitoid rocks are also found on the western side of the Tanakura Tectonic Line (Fig. 1), which is the northernmost area of the SW Japan Zone. We refer to this group of granitoid rocks as the "Niigata area" in this short note. Although a number of Sr isotope and Rb–Sr age data on the granitoid rocks in the Kitakami and Abukuma Belts have been documented (Shibata, 1974 ; Ueno, 1977 ; Shibata and Ishihara, 1979a ; Terakado and Nakamura, 1984 ; Fujimaki et al., 1992 ; Maruyama et al., 1993 and others), there are still only a limited number of data for granitoid rocks in the Niigata area. We have determined a Rb–Sr whole rock isochron age and an initial Sr isotope ratio for the Gozu Granite (Sasada, 1975) in the southern part of this area (Fig. 1). Such geochemical and geochronological data for granitic rocks in this area are important in the examination of the petrogenesis of the intense felsic magmatism which took place over a wide area of the eastern margin of the Eurasian Continent during Cretaceous–Paleogene time.

Geological setting and samples

The Gozu Granite occurs about 40 km east of Niigata city (Fig. 1), and has an outcrop area of about 130 square kilometers. The Gozu Granite discordantly intrudes upper Paleozoic and Mesozoic sedimentary rocks (Chihara, 1959, 1982), and is unconformably overlain by Tertiary sedimentary and volcanic rocks (Saito et al., 1962) (Fig. 2). The petrology of this granitic mass has been studied by Chihara (1950, 1959) and Sasada (1975). Using petrographic criteria, Sasada (1975) subdivided the mass into adamellite, porphyritic adamellite, granite, leucogranite and aplite. The predominant rock types are medium-grained massive adamellite and porphyritic adamellite, which are gradational in the field, and comprise more than 95 percent of the pluton (Sasada, 1975). Based on detailed petrographical and petrochemical data, Sasada (1975) suggested that the pluton was formed by fractional crystallization of a single felsic magma.

We collected seven fresh samples in the southern part of the Gozu Granite for petrochemical and Rb–Sr geochronological work (Fig. 2). Modal compositions of the medium-grained samples collected are plotted on a plagioclase–quartz–K-feldspar triangular diagram (Le Maitre, 1989) (Fig. 3). Four samples plot in the granite field, and one sample (No. 401) plots in the granodiorite field close to the granite join (Fig. 3). These samples exhibit medium-grained equigranular or porphyritic texture, and are composed mainly of quartz, plagioclase, K-feldspar and biotite. Small amounts of hornblende is also present in some samples. Zircon, apatite, allanite and magnetite are common accessory phases. One granite sample (No. 408 A) is leucocratic, and has a higher modal K-feldspar content than the other three granites. Both aplitic granites (Nos. 403 B and 406) are leucocratic, and are rich in K-feldspar.

Analytical procedures

Whole rock major element compositions and Rb and Sr concentrations were determined by X-ray fluorescence spectrometry (XRF) at the Department of Geology, Niigata University, following the methods described by Tamura et al. (1989) and Kawano et al. (1992). We estimate an error of 2% for the Rb/Sr ratio of each sample for age calculation, based on reproducibility of the data. Isotope measurements

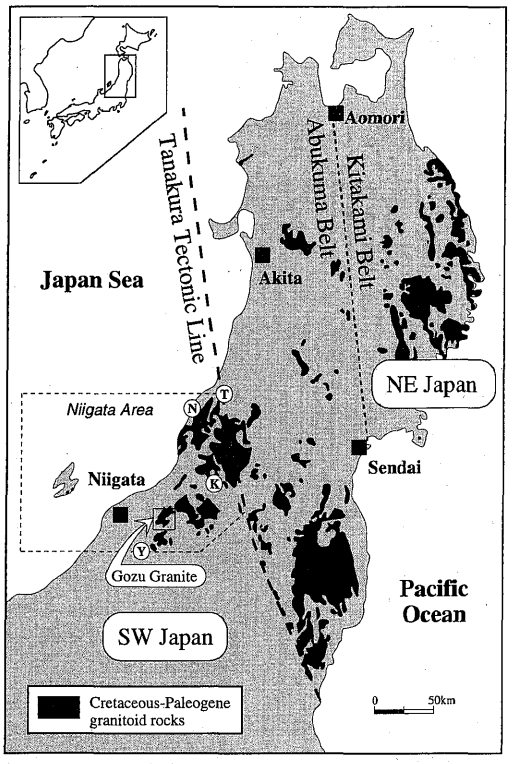

Fig. 1. Distribution of Cretaceous-Paleogene granitoid rocks in the northeast Honshu district.
K : Kanamaru ; Y : Yunotani ; T : Tsuruoka ; N : Nezugasaki

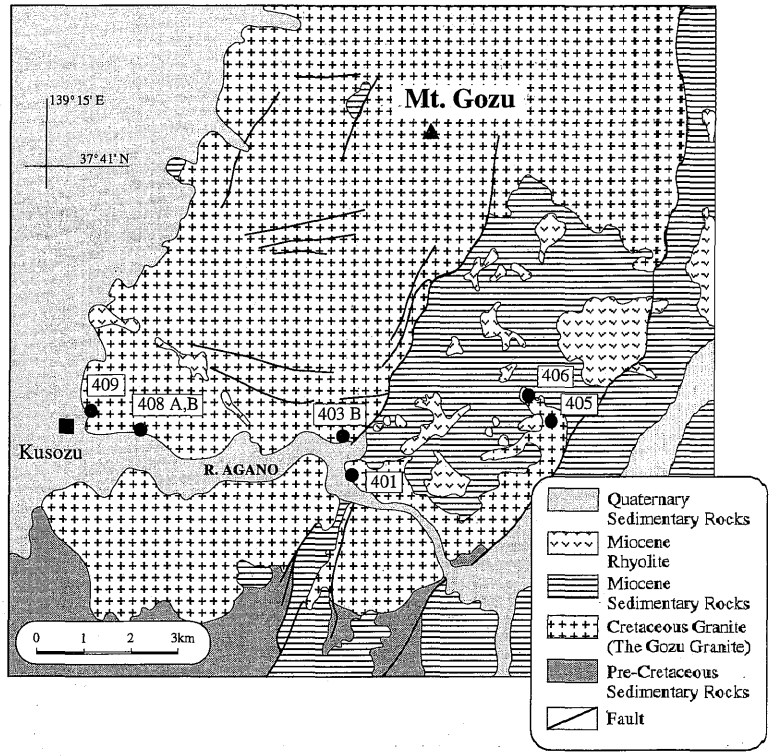

Fig. 2. Geological map of southern part of the Gozu Granite (simplified from Sasada, 1975) and sample localities.
Numbers shown are localities of samples listed in Table 1.

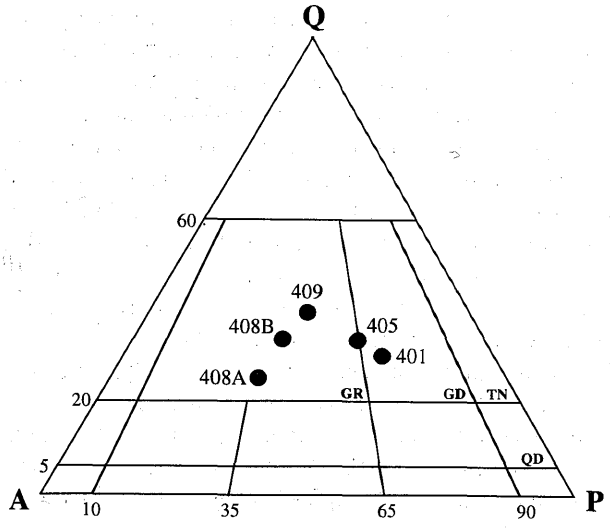

Fig. 3. Modal compositions of the samples.
P : plagioclase ; Q : quartz ; A : K-feldspar. QD : quartz diorite ; TN : tonalite ; GD : granodiorite ; GR : granite.
Numbers shown are samples listed in Table 1. The two aplitic granite samples are not plotted.

were made using a Finigan MAT 262 mass spectrometer at the Department of Geology, Shimane University. Sr was extracted from the samples following by the methods described by Kagami et al. (1987), and mass spectrometric analysis has been described by Iizumi et al. (1994). The total blank for Sr in the whole procedure was 0.6 ng, so the influence of the blank on isotope ratios of the measured samples is negligible. Measured $^{87}Sr/^{86}Sr$ ratios were normalized to $^{86}Sr/^{88}Sr=0.1194$. Sr isotope ratios of NBS 987 were measured twice during this study, giving ratios of 0.710266 ± 0.000009 (2σ) and 0.710264 ± 0.000009 (2σ). The age and initial Sr isotope ratio were calculated after York (1966), using $\lambda=1.42\times10^{-11}\ y^{-1}$ for the decay constant of ^{87}Rb.

Results and discussion

Whole rock chemical and Sr isotope data are listed in Table 1. The granodiorite sample (No. 401) has the lowest silica content of 66.38 wt. percent, but has relatively high K_2O and Rb contents. Granites and aplitic granites have higher silica contents ranging from 69.85 to 77.46 wt. percent. The leucocratic granite (No. 408 A) is characterized by high K_2O and Rb and low CaO and Sr contents. Molar $Al_2O_3/(CaO+Na_2O+K_2O)$ ratios of these samples are mostly lower than 1.1. Petrographical and petrochemical data of these

Table 1. Chemical compositions and Sr isotope ratios of granitic rocks.

Sample No.	401	403B	405	406	408A	408B	409
Rock Type	GD	AG	GR	AG	GR	GR	GR
SiO_2 (wt%)	66.38	74.54	69.89	77.46	75.41	69.85	72.69
TiO_2	0.37	0.09	0.34	0.06	0.04	0.31	0.17
Al_2O_3	16.03	12.96	14.18	12.50	12.78	14.74	13.23
Fe_2O_3(total)	2.81	1.03	2.82	0.26	0.85	2.52	1.57
MnO	0.07	0.06	0.06	0.01	0.08	0.07	0.06
MgO	1.16	0.42	1.21	0.19	0.18	0.96	0.59
CaO	2.10	0.69	1.78	0.86	0.62	2.38	1.49
Na_2O	3.70	3.24	2.84	3.32	3.50	3.25	2.83
K_2O	5.64	5.25	4.55	4.71	5.29	4.52	5.09
P_2O_5	0.13	0.03	0.12	0.01	0.01	0.10	0.06
Ig.loss	1.68	1.41	1.76	0.37	0.58	0.73	1.36
Total	100.07	99.73	99.55	99.75	99.34	99.43	99.13
Rb (ppm)	180	193	171	168	248	154	158
Sr (ppm)	325	67	218	50	30	281	173
$^{87}Rb/^{86}Sr$	1.6	8.3	2.3	9.7	24.0	1.6	2.6
$^{87}Sr/^{86}Sr$	0.707387	0.716353	0.708328	0.718454	0.737132	0.707612	0.708917
(2σ)	±0.000014	±0.000014	±0.000014	±0.000014	±0.000014	±0.000014	±0.000014

GD: granodiorite; GR: granite; AG: aplitic granite

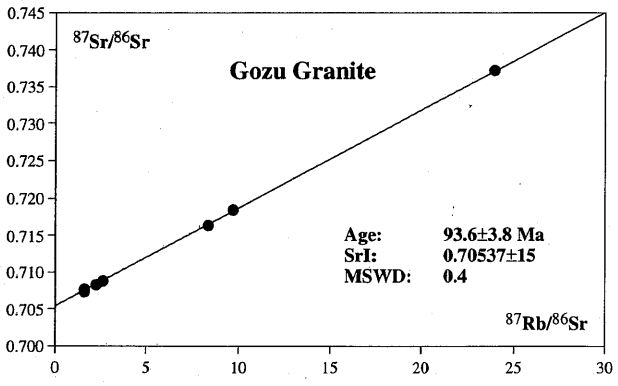

Fig. 4. Rb-Sr whole rock isochron diagram for the Gozu Granite.

samples indicate that the Gozu Granite corresponds to the I-type (Chappell and White, 1974) and magnetite series.

A whole rock Rb-Sr isochron diagram for the Gozu Granite is shown in Fig. 4, giving a well-defined isochron age of 93.6±3.8 (2σ) Ma, with an initial Sr isotope ratio of 0.70537±0.00015 (2σ). This Rb-Sr whole rock isochron age is consistent with a previously reported K-Ar biotite age of 94.1 Ma (recalculated after Steiger and Jäger, 1977) (originally 92 Ma by Kawano and Ueda, 1966). The consistency of the two ages implies that the Gozu Granite cooled down rapidly after emplacement of the magma. Other granitoid rocks in the Niigata area have variable K-Ar biotite and hornblende ages ranging from 54 to 99 Ma (Kawano and Ueda, 1966 ; Shibata and Nozawa, 1966 ; Agency of Natural Resources and Energy, 1982, 1987). Shibata and Ishihara (1979 b) reported a Rb-Sr whole rock isochron age of 81.5 Ma for a granitic pluton at Kanamaru (Fig. 1), which occurs about 50 Km northeast of the Gozu Granite. Thus, the Gozu Granite is one of the oldest granites in this area.

Shibata and Ishihara (1979 b) gave an initial Sr isotope ratio of 0.7060 for the granitic pluton at Kanamaru (Fig. 1). This is slightly higher than the initial ratio of the Gozu Granite. Shibata and Ishihara (1979 a) calculated initial Sr isotope ratios for three other granitoid rocks in this area, assuming their ages are 80 Ma. A hornblende-biotite granodiorite from Yunotani in the southern part of this area (Fig. 1), shows a comparable initial Sr isotope ratio (0.7055) with the Gozu Granite. However, two other granitoid rocks, a hornblende-biotite granodiorite from Tsuruoka and a hornblende-biotite monzogranite from Nezugasaki in northern part of the Niigata area (Fig. 1) have distinctly higher initial Sr isotope ratios (0.7067 and 0.7079) than the Gozu Granite. This indicates that the granitoid rocks in the area have variable initial Sr isotope ratios, compared with the granitoid rocks in the Abukuma and Kitakami Belts, which show restricted ranges in initial ratio from 0.7047 to 0.7058, and from 0.7038 to 0.7049, respectively (Shibata and Ishihara, 1979 a ; Terakado and Nakamura, 1984 ; Shibata and Tanaka, 1987 ; Fujimaki et al., 1991 ; Fujimaki et al., 1992 ; Maruyama et al., 1993).

The Gozu Granite has a similar radiometric age and an initial Sr isotope ratio to some granitoid rocks in the Abukuma Belt, most of which have K-Ar biotite and hornblende ages ranging from 90 to 120 Ma (Kawano and Ueda, 1965 ; Shibata and Uchiumi, 1983). We note that the Gozu Granite, one of the more felsic intrusive suites, has a relatively low initial Sr isotope ratio among the granitoid rocks in the Niigata area.

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