Geochronology on the "Oldest Rock" of Japan

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Abstract—The Kurosegawa structural belt, linearly aligned along the outer zone of S. W. Japan from Kyushu and Shikoku to the Kinki district of Honshu Island contains the oldest rock of Japan both from the paleontological (Silurian fossiliferous limestone) and the geochronological (Rb-Sr age of biotite from the Mitaki granite) points of view.

The Rb-Sr age of the biotite is 428 ± 4 m.y. and that of potassium feldspar in the Kurosegawa belt is 288 ± 19 m.y.

The latter age seems to coincide with the age of upheaval of the belt. As is revealed by microscopic examination, potassium feldspar is characterized by alteration and replacement at low temperature.

GEOLOGY

Our project in isotope geology is conducted in conjunction with the Upper Mantle Project in Japan and with an investigation of the basement rocks of the Japanese Islands. In 1965, the fossil age of the basement rocks in the Japanese Islands was summarized by MINATO *et al.* (1965). On the basis of the fossiliferous sedimentary rocks and field geology, the oldest formation in the Japanese Islands is supposed to be Silurian in age.

The Chichibu Paleozoic formation, which consists mainly of Permian sediments, is widely distributed in the outer zone of the south western part of Japan.

The lenticular granitic or gneissic bodies, which are generally more or less elongated and parallel to the general trend of the surrounding Paleozoic and Mesozoic rocks are found in a belt extending parallel to the Median Tectonic Line over 600 km from Kyushu and Shikoku to the Kinki district (Fig.1.) This belt was named the Kurosegawa structural belt by ICHIKAWA *et al.* (1956). The lenticular bodies consist of the Terano metamorphic rock, the Mitaki granite, serpentinite and fossiliferous limestone, and are in fault relation. The lenses of granite or gneiss attain a maximum width of 1 km and a maximum length of 5 km, but are frequently far smaller with a dimension of 40 m to 50 m.

The occurrence of the Terano metamorphic rocks and the Mitaki granites has been interpreted as a result of the upheaval of the Kurosegawa structural belt. MIYACHI

Fig. 1

(1965) suggested that the gneiss and granite may be of cognate origin because their accessory minerals are of the same kind. The Terano metamorphic rocks occur in the lenticular bodies, often partly or entirely enclosed in Mitaki granites, in the form of a large xenolith. The Mitaki granites are composed of various types of rocks, *e. g.* leuco granite, granodiorite, tonalite and so forth. These rocks do not have metamorphic effect on the Silurian limestone, and, therefore, the granite seems to be older than the limestone. Thus these granites and gneisses must be the oldest rocks in Japan.

Rb-Sr MEASUREMENTS

Analyses were made by two single filament surface ionization mass spectrometers, 9 inches in radius of curvature, manufactured by the Mitsubishi Electric Co. Ltd. Rubidium and strontium were analyzed separately by the two mass spectrometers each equipped with an electron multiplier as a detector. The possible presence of rubidium during the strontium analyses was monitored by scanning the mass 85 region at high sensitivity using the electron multiplier of 12 stages. Table 1 presents data concerning

Table 1 Age of micas

Sample No.	Rock	Mineral	Rb ppm	$^{87}\text{Sr}^*$ ppm	Sr common ppm	$^{87}\text{Sr}^*/^{87}\text{Sr}$ total ppm	Age m.y.
W - 1	Gr-di	Bi	51.07	0.0870	16.0	0.0729	434
S - 1	Gr-di	Bi	115.1	0.1943	32.3	0.0798	430
S - 2	Gr-di	Bi	150.0	0.2432	27.6	0.113	412
S - 3	Gn	Bi	248.2	0.3930	15.1	0.273	402
S - 4	Gr-di	Bi	105.7	0.1737	23.1	0.0977	419
K - 1	Gn	Bi	135.3	0.207	12.3	0.195	389
K - 2	Gr-di	Bi	214.7	0.3564	16.1	0.242	423
			209.1	0.3638	16.5	0.241	443
K - 3	Mus-sch	Mus	233.9	0.3950	246.8	0.023	429
			229.5	0.4090	248.3	0.023	454
K - 4	Gn	Bi	333.6	0.5339	10.5	0.422	407
			355.9	0.557	10.4	0.435	398
K - 5	Gn	Mus	201.4	0.3347	120.1	0.038	422
		Mus	147.5	0.2482	170.5	0.021	428
K - 6	Gn	Bi	57.9	0.1052	23.2	0.061	461
		Mus	140.3	0.2473	106.3	0.032	448
			141.1	0.2439	106.3	0.038	440

Rb-Sr age determinations on the separated micas of the Mitaki granites, reported in part by HAYASE and ISHIZAKA (1967), and of the Terano metamorphic rocks. Since the rocks of the Kurosegawa structural belt show cataclastic texture and are extensively weathered, it is difficult to collect fresh rock specimens.

One of the most troublesome tasks was separation of pure minerals for dating because these rocks were sheared, crushed and even largely changed to chlorite, epidote and prehnite. Before separation of the mineral, we confirmed the existence of surviving

Table 2 Age of K-feldspars

Sample No.	Rock	Mineral	Rb ppm	$^{87}\text{Sr}^*$ ppm	Sr common ppm	$^{87}\text{Sr}^*/^{87}\text{Sr}$ total ppm	Age m.y.
S - 5	Gr	Kf	218.9	0.2165	308.7	0.010	251
K - 7	Gr	Kf	347.3	0.4594	58.5	0.101	337
K - 8	Gr	Kf	95.34	0.0936	39.6	0.033	250
K - 9	Gr	Kf	515.8	0.5685	59.5	0.121	280
K - 10	Gr	Kf	373.5	0.5230	185.5	0.0389	355
K - 11	Gr	Kf	381.9	0.3819	65.74	0.077	254

* Radiogenic

biotite by microscopic observation.

The Rb-Sr data given in Table 1 indicate that the oldest mineral age of Japan for the separated fresh biotite and muscovite is 428 ± 4 m.y.

But the age of potassium feldspar given in Table 2 is 288 ± 19 m.y. which is younger than that of micas.

The ages listed here are calculated with the following constants:

$$\lambda_{\text{Rb}} = 1.39 \times 10^{-11}/\text{y},$$

Common strontium

$$^{86}\text{Sr}/^{88}\text{Sr} = 0.1194$$

$$^{87}\text{Sr}/^{86}\text{Sr} = 0.7115$$

Rubidium

$$^{85}\text{Rb}/^{87}\text{Rb} = 2.89 \text{ (in atomic ratio).}$$

With reference to the above mentioned tentative value of $^{87}\text{Sr}/^{86}\text{Sr}$, isotopic ratio of common strontium was measured for epidote separated from the Mitaki granites. The following data were obtained:

$$^{86}\text{Sr}/^{88}\text{Sr} = 0.1195$$

$$^{87}\text{Sr}/^{86}\text{Sr} = 0.7116$$

Plate 1

Plate 2

These two values of $^{87}\text{Sr}/^{86}\text{Sr}$, (0.7115 and 0.7116) coincide with each other. This paper is not intended to discuss the problem of initial ratio of strontium because there seem to be very complicated relations between rocks and minerals. We are now carrying out an investigation into the petrogenetic relation of strontium isotope ratio of these rocks.

There seems to be an inverse relation between the ages of micas and potassium feldspar when compared with ordinary cases, though BROOKS (1966) already reported the same age relation between biotite and potassium feldspar, and ARREINS *et al.* (1966) demonstrated a pattern of isotopic redistribution. According to microscopic observation, the age of micas seems to represent the original age and that of potassium feldspar represents the age of the formation of prehnite and epidote veinlets.

Plates 1 and 2 show a replacement veinlet of potassium feldspar. This veinlet seems to have been formed at the stage of the upheaval of the Kurosegawa structural belt.

As stated above, the Mitaki granites are sheared by the movement of an upheaval, and invaded reticulately by very fine veinlets of epidote and prehnite. Microscopic examination reveals that tiny veinlets of epidote and prehnite cut through the potassium feldspar and become dotted with spots of recrystallized potassium feldspar.

Unfortunately, we could not obtain a specimen of Mitaki granite including both

biotite and potassium feldspar, because rock with biotite does not contain fresh potassium feldspar and inversely rock with potassium feldspar does not contain surviving fresh biotite.

The dated potassium feldspar samples seem to be recrystallized and partly replaced by veinlets of calcite, epidote, prehnite and quartz.

As stated by MIYACHI (1966) in his description as to the age of the Kurosegawa tectonic movement, granitic conglomerate pebbles of middle Permian formation are of the Mitaki granite.

The biotite age of the altered Mitaki rocks was calculated at 209 m.y. with the K-Ar method by KAWANO and UEDA (1966), and at 191 m.y. with the Rb-Sr method by HAYASE and ISHIZAKA (1967). The reduced age in the latter data might be due to the same effect as in the case of the potassium feldspar.

Figure 2. shows the mineral isochron of the Mitaki and Terano rocks. All the $^{87}\text{Sr}/^{86}\text{Sr}$ ratios are calculated from the data on the age of the separated mica. The isochron obtained by a least squares fit, has a slope corresponding to an age of 426 m.y., assuming $1.39 \times 10^{-11}/\text{y}$ for the ^{87}Rb decay constant, and an intercept corresponding to an initial $^{87}\text{Sr}/^{86}\text{Sr} = 0.711$.

CONCLUSION

The age determination was made by the Rb-Sr method for 13 samples of mica and 6 samples of K-feldspar in the granitic and gneissic rocks from the Kurosegawa structural belt.

The average age of these minerals is 428 ± 4 m.y. The mica ages of the Mitaki granites and the Terano metamorphic rocks fall into an average range of 389 m.y. to 443 m.y. and 428 m.y..

From the present age data, it may be assumed that in the Kurosegawa structural belt, the metamorphic gneiss is cogenetic with the granitic rock and can be correlated with the middle Silurian age.

The age of the potassium feldspar of the Mitaki granites is given as 288 ± 19 m.y. and as evidenced by microscopic observation this age seems to indicate the upheaval age of the Kurosegawa rocks.

Fig. 2

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