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Potassium-Argon Ages of the Granitic Rocks in the Vicinity of Ningyō-tōge, Chūgoku District, West Japan

By

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Abstract

The K-Ar age determination was made on biotites separated from five granitic rocks in the vicinity of Ningyō-tōge, Chūgoku district, West Japan. The experimental techniques are briefly described. The ages range from 33 to 64 million years. The ages represent a nearly equal period of intrusion, i. e., the early Paleogene, excluding the youngest one (OT 1003), which is not reasonably explained with the present geological and petrographical evidences.

Introduction

In the Chūgoku district, there are the vast outcrops of granitic rocks which are commonly called as Cretaceous Chūgoku batholith as a whole. They are known to have been intruded into the Permo-Carboniferous formations, the early Cretaceous Kwanmon group and its related volcanic rocks, and unconformably covered by the Neogene rocks. Therefore, the age of intrusion is thought by most geologists to be the late Cretaceous or Paleogene period.

Up to the present, only two specimens were dated on Chūgoku granites by Dr. K. Hayase of Kyōto University[1], and he obtained the values of the ages (million years) as 50 and 45 by the K-Ar method and 130 and 65 by the Rb-Sr method, respectively.

Recently N. Yamada, one of the authors, has made clear with his collaborators (M. Murayama et al.) that the activities of the granitic rocks can be divided into three

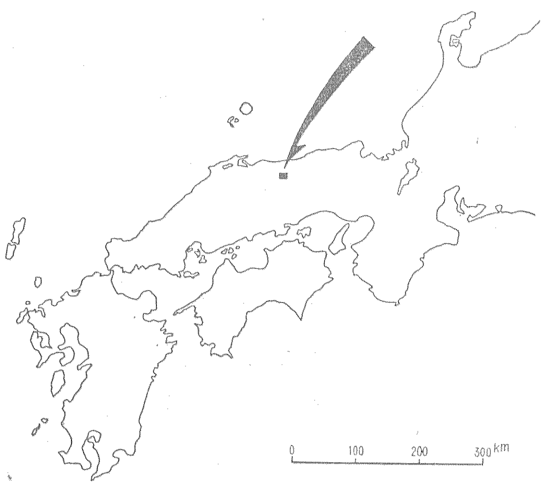

Fig. 1 Index map showing the sampling area

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stages in the vicinity of Ningyō-tōge, northeastern part of Chūgoku district.[2)3)] Namely, the intrusive rocks of the 1st stage are ranging from gabbro to granite-granophyre in composition and occur, in the most parts, as small xenolithic bodies captured by the later intrusives. On the other hand, the intrusives of the 2nd and 3rd stages constitute the main part of Chūgoku batholith, and comprise hornblende-biotite granodiorite, hornblende-biotite granite and biotite granite in the former and only leucocratic biotite granite in the latter.

Of the dated specimens reported here, one (OT 1003) from the intrusives of the 1st stage, three (OT 1001, AN 116 and AN 119) from the 2nd and one (KY 1001) from the 3rd were collected. Among these, AN 116 and AN 119 were given by Dr. A. Ando of the Geological Survey. Other specimens were collected by N. Yamada. Fig. 1 and Fig. 2 show the sampling area and the location of specimens, respectively.

The K-Ar age measurement was made by K. Shibata, and geological consideration and description of specimens were made by N. Yamada.

Description of the Specimens

OT 1003 Biotite from fine-grained biotite granite

Locality: Outcrop by the road between Anagamo and Ningyō-tōge, Misasa-chō, Tōhaku-gun, Tottori prefecture

Geology: Belongs to intrusives of the 1st stage. This rock is close to a fault having east-west trend which bounds the granite and the late Mesozoic volcanic rocks (mainly composed of andesite tuff-breccia) and is, in its southern extension, intruded into the above volcanic rocks.

Petrography: Modal composition in volume percent is: plagioclase, 41; quartz, 33; potash feldspar, 22; and biotite, 4. This rock is mostly homogeneous and leucocratic, but sometimes bears the small basic ovoid inclusions. Biotite is flaky, less than 1 mm in length and almost free from any alterations. Refractive index (γ) of biotite is 1.660 ± 0.001 and the pleochroism is from pale yellowish brown (X) to deep brown ($Y \fallingdotseq Z$).

OT 1001 Biotite from medium-grained hornblende-biotite granodiorite

Locality: Outcrop by the road between Shimohata and Sangenya, Misasa-chō, Tōhaku-gun, Tottori prefecture

Geology: Belongs to intrusives of the 2nd stage. This is intruded into the biotite-hornblende-pyroxene-quartz gabbro, the fine-grained biotite granite (similar to OT 1003) and the late Mesozoic volcanic rocks in its southern extension, and is intruded by the coarse-grained biotite granite of the 3rd stage 500 m to the north of this locality.

Petrography: Modal composition is: plagioclase, 44; quartz, 30; potash feldspar, 15; biotite, 7; hornblende, 2; and others, 2. This rock bears numerous basic ovoid inclusions, and is sometimes highly contaminated. Biotite is rather coarse and its maximum length reaches to 5 mm. Refractive index (γ) of biotite is 1.660±0.001 and the pleochroism is from pale yellowish brown (X) to deep brown (Y≒Z). Chloritization of biotite is weak but distinct.

AN 116 Biotite from medium-grained hornblende-biotite granodiorite

Locality: Outcrop by the road between Ningyō-tōge and Akawase, Kamisaibara-mura, Tomada-gun, Okayama prefecture

Geology: Belongs to intrusives of the 2nd stage. This rock occurs as a body less than 500 m in diameter included in the coarse-grained hornblende-biotite granite of the same stage.

Petrography: Modal composition is: plagioclase, 50; quartz, 25; potash feldspar, 13; biotite, 8; hornblende, 3; and others, 1. Rock features are similar to OT 1001. Refractive index (γ) of biotite is 1.663±0.001 and the pleochroism is from pale yellowish brown (X) to deep brown (Y≒Z). Chloritization of biotite is highly conspicuous and, accordingly, the low value of K_2O content as shown in Table 1 can be attributed to such alteration.

AN 119 Biotite from coarse-grained hornblende-biotite granite

Locality: Outcrop by the road between Ningyō-tōge and Ishigoshi, Kamisaibara-mura, Tomada-gun, Okayama prefecture

Geology: Belongs to intrusives of the 2nd stage. This granite is covered, 500 m to the north of this locality, unconformably by the uraniferous Ningyō-tōge formation of the early Pliocene in age.

Petrography: Refractive index (γ) of biotite is 1.663±0.001. Chloritization of biotite is distinct.

KY 1001 Biotite from coarse-grained biotite granite

Locality: Outcrop by the road between Ogōchi and Tarōda-Yashiki, Misasa-chō, Tōhaku-gun, Tottori prefecture

Geology: Belongs to intrusives of the 3rd stage and shows the most

Table 1 Results of K-Ar Age Determination

Specimen No.	Rock	Mineral	K_2O (%)	Atmospheric contamination (%)	Age and estimated error (million years)
OT 1003	granite	biotite	7.36	36.1	36±5
				42.0	33±5
				40.7	39±5
OT 1001	granodiorite	biotite	6.57	8.8	49±6
				16.9	50±6
AN 116	granodiorite	biotite	5.12	28.6	64±6
AN 119	granite	biotite	6.88	16.3	57±3*
KY 1001	granite	biotite	5.48	17.1	57±6
				30.6	62±6

$\lambda_\beta = 4.72\times10^{-10}yr^{-1}$, $\lambda_e \doteq 0.584\times10^{-10}yr^{-1}$

* Argon analysis made at the Department of Geodesy and Geophysics, Cambridge.

representative facies of this stage. This granite is fairly intruded into hornblende-biotite granodiorite of the 2nd stage 500m to the south of this locality.

Petrography: Modal composition is: quartz, 37; microcline-perthite, 34; plagioclase, 26; and biotite, 3. This rock is leucocratic with pinkish tinge in color, mostly homogeneous over the wide area and bears no basic inclusions for the most parts. Average size of biotite is 2–3 mm in its maximum length, refractive index (γ) of it is 1.659 ± 0.001 and the pleochroism is from pale yellowish brown (X) to deep brown ($Y \doteqdot Z$). Chloritization of biotite is distinct, as expected from the low value of K_2O content as shown in Table 1.

Experimental Techniques and Results

The K-Ar age determination is made on biotites separated from rock specimens.

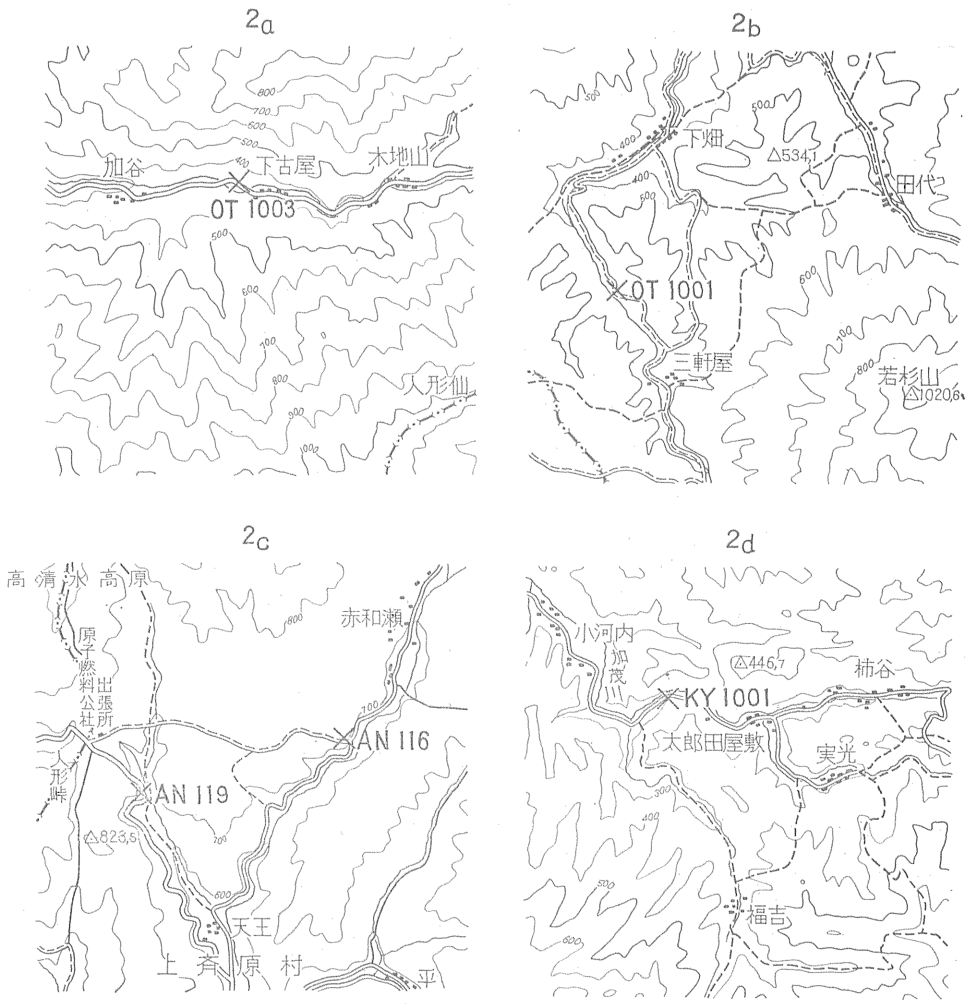

Fig. 2 Maps showing the location of the specimens
Figs. 2a, 2b, and 2c are parts of "Okutsu" sheet map (1 : 50,000), and Fig. 2d is a part of "Kurayoshi" sheet map (1 : 50,000).

The rock is crushed, ground, sieved, and the size fraction of $-40+70$ mesh is used for OT 1003, OT 1001, KY 1001, and $-20+30$ mesh is used for AN 116 and AN 119. Separation of biotite is made first with a 7-pole electromagnetic separator, then with a Franz-type isodynamic separator. For final purification methylene iodide is used on OT 1003 and OT 1001.

Potassium analyses are done by flame photometry. Biotite is digested with hydrofluoric acid and hydrochloric acid, the residue is dissolved in hydrochloric acid, diluted to the standard volume, and the potassium content of the solution is determined with the HITACHI EPU-2 type flame photometer.

Argon extraction and purification are made in the pyrex high vacuum system. From 5 to 10 g of biotite in the molybdenum crucible is placed in the quartz tube which is attached to the pyrex tube by a graded seal, and fused at about 1300°C for 30 minutes with an induction heater. The Ar^{38} spike is added during fusion, and the purification of evolved gases is made by titanium sponge at about 900°C and CuO at about 450°C. The isotopic ratios of argon are measured with the HITACHI RMU-5 type mass spectrometer by the flow method. The argon analysis of AN 119 was made by K. Shibata at the Department of Geodesy and Geophysics, University of Cambridge. The details of this analysis will be reported elsewhere.

The constants used in the calculation of K-Ar ages are: $\lambda_\beta = 4.72 \times 10^{-10} yr^{-1}$, $\lambda_e = 0.584 \times 10^{-10} yr^{-1}$, and $K^{40} = 1.19 \times 10^{-2}$ atom per cent.

The results of K-Ar age determination are given in Table 1.

Discussion

The K-Ar ages of biotites from the Chūgoku granites are not inconsistent, as a whole, with hitherto accepted geological evidences. The ages range from 33 to 64 million years with an average of 53 million years, and, if the youngest one (OT 1003) is excluded, the remainders range from 49 to 64 million years with an average of 57 million years. This difference in age among the remainders is within the limit of experimental error, so it is considered that the K-Ar ages represent, at a present grade of experimental accuracy, a nearly equal period of intrusion, namely, the early Paleogene after Kulp's time scale.[4)]

Concerning the youngest age dated (OT 1003), there exist some troublesome problems. Geologically, this granite is thought to have been intruded and consolidated in the earliest stage among the granites dated here. Nevertheless, repeated potassium and argon determinations of the specimen always gave 30–40 million years (late Paleogene), and hence this significance is not to be judged in term of experimental errors. Moreover, biotite of this granite is almost free from chloritization as suggested from its highest value of K_2O content among the biotites dated here, so it is not considered from the present petrographical evidence that the argon diffusion had taken place most severely in the biotite of this granite. At present, we have no idea to explain this age reasonably in connection with geological and petrographical evidences.

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中国地方・人形峠付近の花崗岩類のカリウム-アルゴン年代

柴田 賢　山田 直利

要　旨

中国地方北東部の人形峠付近に分布する花崗岩類は，従来の地質学的資料によれば，白亜紀後期ないし古第三紀に生成したものとされている。今回この花崗岩類 5 個から分離した黒雲母について，カリウム—アルゴン法により年代測定を行なった。試料のうち 4 個の年代は，50, 57, 60, 64×10^6 年であり，いずれも古第三紀前期に相当する。他の 1 個は 36×10^6 年の年代を示し，上記のものよりかなり若い。