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A Trial Method of Determining Uranium and Thorium Content of Rocks in Radioactive Disequilibrium by Neutron Activation Analysis (2)

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Abstract

In the first paper was reported the uranium and thorium content of some basic lavas determined by using neutron activation method. Additional data are presented in this paper. As the result, it seems that Th/U ratio of basaltic lava of historical age is higher than that of andesitic one, and that the radium content of tholeiite lava is approximate to the equilibrium quantity with its uranium, while that of alkali olivine basalt lava highly excessive.

Introduction

Most of the data of uranium content of rocks hitherto appeared are those deduced from radium content determined on the assumption that uranium and thorium are in radioactive equilibrium. For the rocks younger than the time required for establishment of radioactive equilibrium, it is obviously not proper to make such an assumption, because during differentiation and consolidation of the magma, uranium and radium will behave differently according to their chemical properties. Moreover, re-fusion and assimilation will cause a loss of balance between uranium and radium.

The final aim of the present investigation is to obtain data of content of radioactive elements in rocks useful for estimation of heat flow in the crust, but it seems that some interesting petrological or geological problems exist in connection with disequilibrium of radioelements, especially in basic effusive rocks.

In the first paper[1], some results on lavas from Sakurajima, Kirishima, Aso and Hakone were presented. In this paper, newly obtained uranium and thorium content of basic lavas from other localities, and as a reference, radium content of

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lavas hitherto obtained by other authors are summarized. Of the samples used, Hawaii lavas were those kindly offered by Prof. N. IKEBE of The Osaka City University.

The principle and procedure of the determination of uranium and thorium content by utilizing neutron activation analysis were fully described in the first paper[1] and therefore, omitted here.

Brief notes on the samples

The samples used in the present study are listed in Table 1. They are mostly

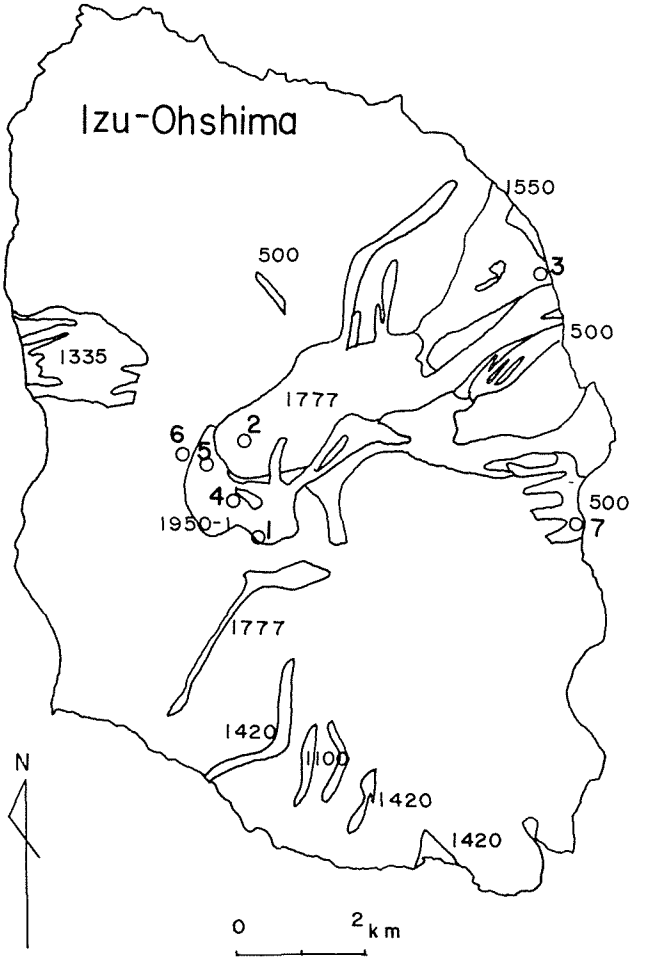

Fig. 1. Sampling sites in Izu-Ohshima: the numerals associated with sample numbers show the times of eruption of the lava concerned.

Table 1. Samples used in the uranium and thorium determinations.

Sample	Time of eruption	Rock type	Locality
Aso ejecta	1965	andesite	Central crater, Aso Volcano
Asama lava	1783	andesite	Oni-no-oshidashi, Asama Volcano
Izu-Ohshima lava[2]			
1	1912	basalt	Central crater
2	1777	basalt	Caldera
3	1550–(1684)	basalt	Komashita-tarô
Miyakejima lava[3]			
1	1962	basalt	Sanshichi-yama
2	1940	basalt	Hyotan-yama
3	1874	basalt	Tosa
4	1835	basalt	Kasaji
5	1763–1769	basalt	Kuribe
Hawaii lava			
Kilauea Iki			
1	? historic	basalt	Lava cascade of Paliokeowe Pali
2	1954	basalt	Halemaumau
Mauna Loa			
1	? historic	basalt	Eastern foot of Mauna Loa

lavas from islands in Pacific Ocean, namely Izu-Ohshima and Miyakejima about 100 km and 164 km SWW of Tokyo Haneda Airport respectively and Hawaii Islands. The sampling sites in the former two islands are shown in Fig. 1 and Fig. 2, in which the numerals are the times of eruption of the lavas concerned.

Results and concerning data

In Table 2, uranium and thorium contents determined by using neutron activation analysis are listed. On the rocks from Izu-Ohshima, Miyakejima and Hawaii Islands, several authors[4)5)6)7)] have made the radium determinations and the results are summarized in Table 3. The figures shown under the heading eq. U in Table 3 are the values of uranium content calculated from radium content on the assumption of radioactive equilibrium between uranium and radium.

As to the results hitherto obtained, two points may be worth mentioning.

(i) Th/U ratios range from 2.3 to 3.7 for lavas from Sakurajima, Kirishima and Aso volcanoes in Kyūsyū district, and those from Hakone and Asama volcanoes, while most of the lavas from islands, Izu-Ohshima, Miyakejima and probably also Hawaii, show higher Th/U ratio. Considering that the former group of lavas are andesite and the latter basalt, this tendency nearly corresponds to the result by EVANS and GOODMAN[7)] that the average ratios for intermediate and basic rocks

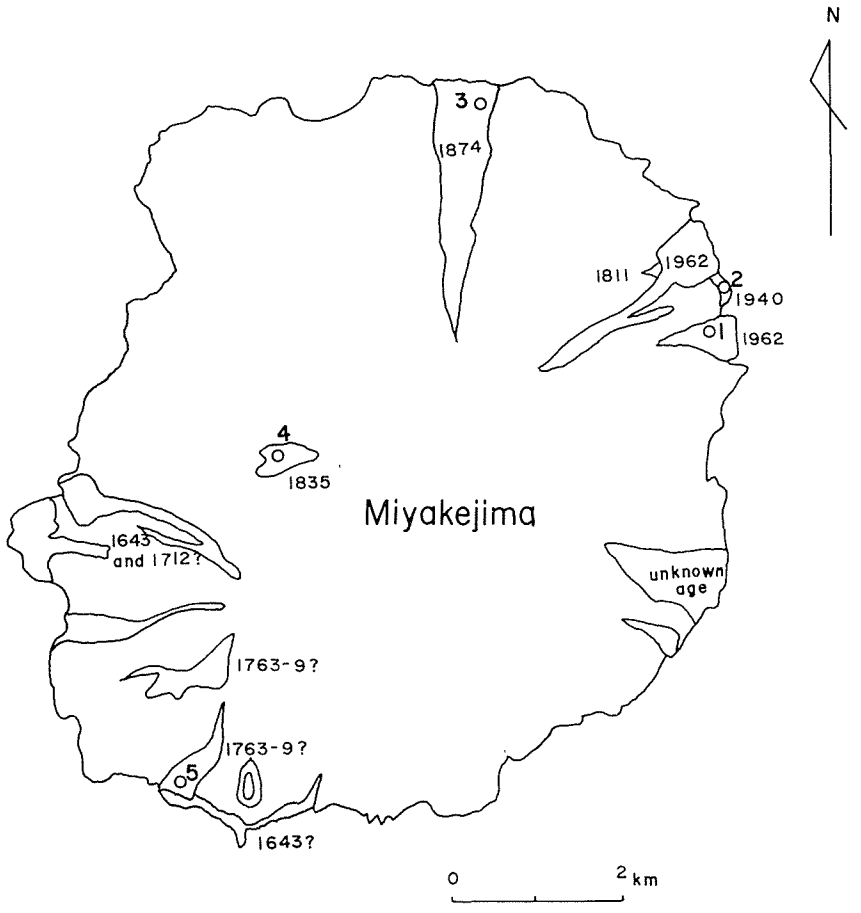

Fig. 2. Sampling sites in Miyakejima: the numerals associated with sample numbers show the times of eruption of the lava concerned.

are respectively 2.6 and 4.0. Whether such a discrepancy is *a priori* or *posteriori* is not yet decided.

(ii) For the igneous rocks younger than 10^6 years, it is naturally considered that the content of radium is less than the equilibrium amount to uranium, as the Ra/U ratio in equilibrium is about 3.5×10^{-7}. As shown in Table 3 of the first report[1], Table 2 and Table 3 in the present paper, andesite lavas from Kyûsyû district and most of the basaltic lavas of Hawaii unexpectedly reveal quite excessive content of radium.

Assuming that radium determination was correct, and putting aside the same question "*a priori* or not", there arise a possibility that the radium content of tholei-

Table 2. Uranium and thorium content.

Sample	U ppm	Th ppm	Th/U
Aso ejecta	0.8	2.3	2.9
Asama lava	0.8	1.7	2.1
Izu-Ohshima 1 (Meiji-Taisho lava)	0.8	3.0	3.8
2 (An'ei lava)	0.7	3.1	4.4
3	0.6	3.5	5.8
Miyakejima 1	0.6	3.1	5.7
2	0.5	2.9	5.1
3	(under determination)		
4	0.5	2.9	5.1
5	0.6	2.9	4.8
Hawaii Kilauea Iki 1	0.5	1.8	3.6
2	0.4	2.1	5.2
Mauna Loa 1	0.4	1.2	3.0

Table 3. Radium content and equilibrium quantity of uranium calculated from radium content.

Sample	$Ra \times 10^{-12}$ g/g	eq. U ppm	Reference
Izu-Ohshima			
Miharayama An'ei lava	0.10	0.29	Kimura and Hamaguchi[4]
Miharayama Meiji-Taisho lava	0.13	0.38	"
Izu-Ohshima (average of 5 samples)	0.12	0.35	"
Miyakejima (average of 4 samples)	0.12	0.35	Iwasaki[5]
Hawaii			
Halemaumau 1921	0.94	2.8	Piggot[6]
Ancient lava, north edge of Kilauea	0.94	2.8	"
Andesite basalt, Mauna Loa	0.94	2.8	"
Hawaiian basalt*	1.25	4.3	Joly[7]
Hawaiian basalt*	0.15	0.51	Evans and Goodman[7]

* The same lava sample for intercheck measurement.

ite lavas will be normal with respect to uranium content, while that of alkali olivine basalt lavas highly excessive.

The above-mentioned two points are only a suggestion, and in order to get any definite conclusion, more data are required. Fortunately, fifteen samples of Hawaiian lava of known locality and age of eruption have recently become available through the kindness of Dr. Richard S. FISKE of Hawaiian Volcano Observatory, U.S. Geological Survey. The activation analysis of uranium and thorium of these Hawaiian samples are now under way and also radium determination of the same and rocks from Izu-Ohshima and Miyakejima are in preparation.

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