MEMOIRS OF THE COLLEGE OF SCIENCE, UNIVERSITY OF KYOTO, SERIES B,
Vol. XXV, No. 2 Geology and Mineralogy, Article 5, 1958

Variation in Radioactivity across Igneous Contacts (The Second Report)

By

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(Received Sept. 18, 1958)

Abstract

This is the second report treating the distribution of radioactive elements across igneous contacts. Up to the present, 73 traverses have been examined for the radioactivity. As a result, it was found that the profiles of radioactivity are not at random, but to be reducible to four types which are presumably corresponding to the conditions under which contact phenomena were taken place.

Introduction

Most of the present inferences concerning the problem of the origin of granite have been deduced from geological field evidences and laboratory examinations of sample specimens. A new approach attempted is reported in this paper, in which the radioactive distribution relevant to the problem is presented. The main thing is interpretation of the accumulating evidences on radioactive distribution across igneous contacts, which provides informations about the distribution of radioactive elements. Concerning igneous contacts, BOTT[1] studied by gravity survey, HENSON[2] by distribution of trace-element, DENNEN[3] by chemical composition. The writers also have taken much interest in this problem since 1955 and reported a paper in 1956[4]. The samples tested were collected from North-East District, Middle District, Chûgoku District, Kinki District and Shikoku District of Japan.

Method of investigation

Since 1956, 78 sites of contact have been studied by the radioactive method for the purpose of determining the variation of radioactivity across igneous contacts. A series of specimens collected along a line perpendicular to the observed contact, was pulverized to the fineness to path through 28 meshes. The meaning of adopting this grain size, as well as the detail of the method of measurement was reported in 1956[4], and therefore, was omitted in this paper, except the results of calibration of the radioscope which is different from that previously used.

Standard Rocks*	Shifting Rate of Indicator	Radium Content
Granite-ville Granite	0.530±0.006 div/min	3.3 $\pm 0.2 \times 10^{-12}$ g/g
Columbia River Basalt	0.115±0.006	0.33±0.03
Deccan Trap	0.100±0.007	0.21±0.04
Gabbro Diorite	0.082±0.004	0.18±0.02

* These samples were afforded by U. S. BUREAU of Standard with the certificates of their radium contents.

Some descriptions on geology of the localities where samples were taken from

Kitakami Region

The granitic rocks of the main part of Kitakami mountainland in North-East part of Japan are divided roughly into those of the inner intrusive region and of the outer intrusive region. The area coming into the present examination belongs to inner intrusive region and the east part of Hisume-Kesenuma Tectonic Lines. In this area Paleozoic formations, granitic rocks and ultrabasic rocks probably of Mesozoic era are extensively developed.

Metamorphic rocks of Paleozoic formations :—

The Paleozoic rocks are metamorphosed into hornfels in the contact aureols of about 1.5~3 km width around the granodiorite masses. These metamorphic rocks are (1) hornfels developed along the Tôno granodiorite and (2) hornfels along the Hitokabe granodiorite.

Ultrabasic rocks :—

The ultrabasic rocks form intrusive masses in the Paleozoic formations. They are peridotite, diallagite and hornblendite. The Miyamori ultrabasic rocks are metamorphosed by the intrusion of the Hitokabe granodiorite.

Porphyritic rocks :—

The rocks occur as dykes or stocks intruding into the Paleozoic sediments and peridotite. They range from diorite, porphyrite to spessarite. Some of them are metamorphosed by the intrusion of granodiorites.

Felsic rocks :—

The felsic rocks intruded into the ultrabasic rocks and the Paleozoic formations. They are whitish gray in color, fine-grained, compact, and homogeneous.

Massive diorite-gabbro :—

The diorite-gabbroic rocks intruded into Paleozoic formations.

Granodiorites :—

The rocks form large intrusive masses in the Paleozoic formation and ultrabasic rocks. They are divided into two types, the Tôno and Hitokabe granodiorites, though they sometimes resemble each other in rock features.

The characteristic features of the Tôno granodiorites are as follows: 1) Somewhat schistose and brittle; 2) heterogeneous in mineral composition at the margin of the mass; 3) having euhedral or subhedral hornblende and anhedral biotite, and 4) not so cataclastic.

The typical radioactivity distributions found across contacts are shown in Fig. 1 in which the ordinate shows radioactivity expressed in the shifting rate (div/min) of the indicator of the radioscope, and the abscissa a distance from the contact boundary in meters.

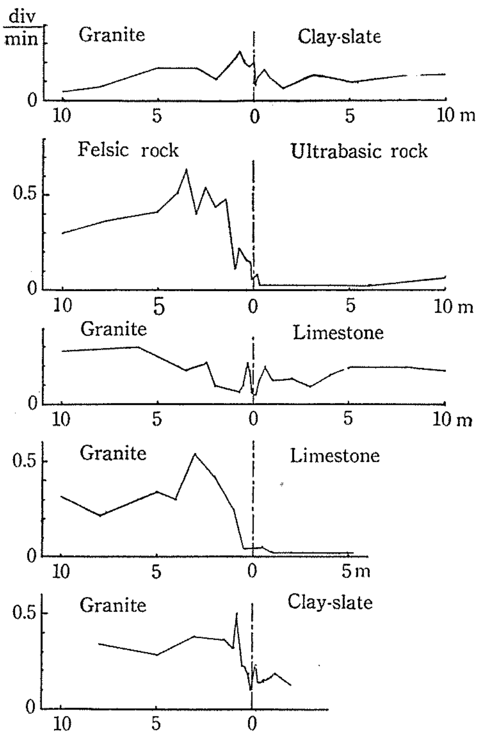

Fig. 1. Radioactive profiles. (Kitakami region)

Abukuma Plateau

In this district, schistose granite intruded in Gozaisho and Takenuki series consisting of pyroxinite, amphibolite, phyllite, biotite-schist and mica-schist. This intrusion occurred after Paleozoic era and before upper Cretaceous period.

According to M. GORAI[5)], these plutonic rocks are divided into the following groups. Group 1: Small sheet of basic rocks (metadiabase and metagabbro). Group 2: Batholith of tonalite, trondjemite etc. situating in the south part of Iritono fault. Group 3: Batholith of granodiorite and adamellite situating in the north part of Iritono fault.

The samples were collected from group 1 and 2, and group 2 is named "Old second stage plutonic rocks" by Abukuma-studing group.

These rocks represent the main part of batholithtic intrusion, forming the main part of Abukuma Plateau. Before the intrusion of these granitic rocks, diabase and gabbro intruded. These rocks have been altered into metadiabase and metagabbro. Granitic rocks are generally of excellent gneissose structure. The principal components are feldspar resembling a strip of paper in shape, quartz, biotite and amphibolite.

In Fig. 2 are shown the representative radioactivity distribution across igneous contacts found in this district.

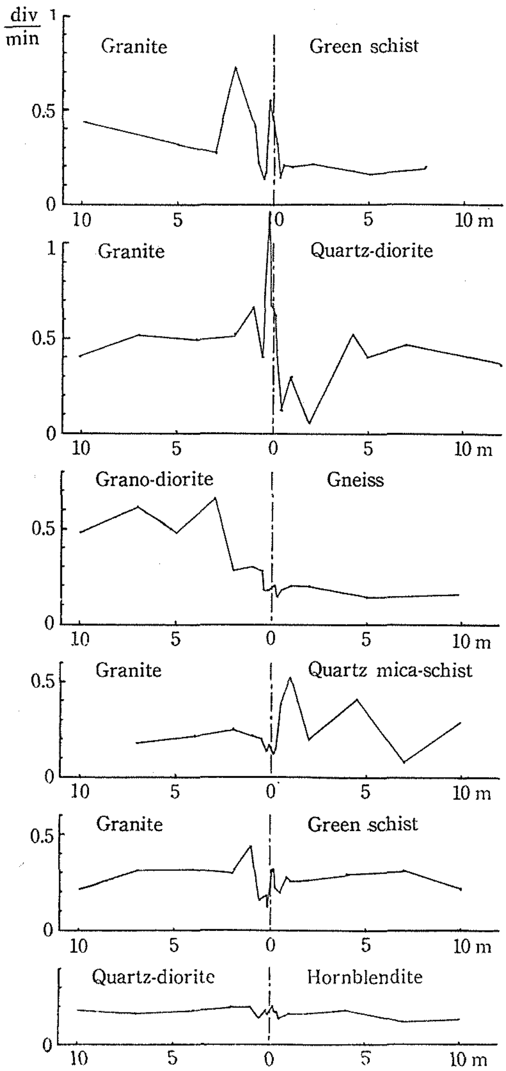

Fig. 2. Radioactive profiles. (Abukuma Plateau)

Ryôke Metamorphics (near Horaiji)

In this district, the base rocks consist of Ryôke metamorphic rocks and granitic rocks, and are covered by volcanic rocks.

Ryôke metamorphic rocks :—

Ryôke metamorphic rocks include biotite-schist, biotite-hornfels, biotite-gneiss, quartz-schist and a less amount of diopside-schist. Biotite-schist and biotite-hornfels are slightly massive and dense. Biotite-gneiss is medium- to fine-grained, light colored and including mainly quartz and feldspar. Quartz-schist is grayish white or white gray.

Biotite-granite :—

The contact of Ryôke rocks with this biotite-granite is zigzag in form. This rock is coarse- to medium-grained, light colored, and includes biotite spots. The principal components are quartz, orthoclase, plagioclase, biotite and muscovite. Accessory minerals are garnet, tourmaline, apatite and zircon. Quartz is most abundant. Biotite is more than either feldspars, while muscovite is few in quantity.

Biotite-hornblende granite :—

This rock intruded into the Ryôke metamorphic rocks with smooth, sharp boundaries. This is generally homogeneous. The principal components are quartz, plagioclase, hornblende and biotite.

Two-mica granite :—

This is of the latest stage intrusion. This is white to greenish white in color, fine-grained and of normal granite texture. It intrudes into mica-schist and schistose-granite in the form of dyke, sheet of irregular mass.

The representative radioactive distribution across contacts are shown in Fig. 3.

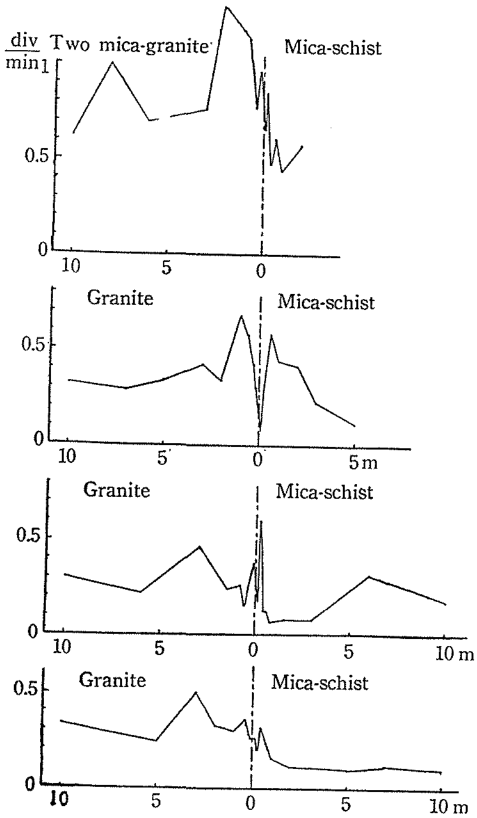

Fig. 3. Radioactive profiles. (near Horaiji)

Kumano Acid Rocks

Microspheric biotite rhyolite :—

Samples were collected from contacts of microspheric biotite rhyolite and Miyai groups at Yamamoto, Mitsuno Village. This rock injects in Miyai groups and is injected or covered by biotite-granite porphyry. This rock has an excellent horizontal joint with an interval of 15~50 cm. Fresh rock is bluish gray in color and decomposed rock is brownish green, and therefore it is very similar to persemic-biotite rhyolite. With the naked eye, we can recognize phenocrysts of quartz, feldspar and greenish biotite.

Biotite-granite porphyry :—

In this rock phenocrysts of quartz, feldspar and some biotite are recognized in massive and fine groundmass, and greenish irregular part of gathering of green mineral, biotite and iron ore. Then this rock is greenish.

This rock is classified by M. MURAYAMA into following three types; (1) micrographic type, (2) microgranite type and (3) glassy to crypto- and micro-crystalline type. The first type occupied the center, the second type the greater part and the third type the margin of this rock mass, but transitions from (1) to (2); and (2) to (3) are fairly gradual. The first type and the second type do not differ except for groundmass and have phenocrysts of quartz, alkali feldspar, plagioclase and biotite.

Groundmass of the third type is glassy to crypto- or micro-crystalline extinctly differed from those of the formers and phenocrysts are quartz, alkali feldspar, plagioclase and biotite which is deformed by crush movement. Biotite is more fresh and larger than that in the formers. This rock is similar to persemic-biotite rhyolite, and injects in Miyai groups giving a slight contact metamorphism to them.

Persemic-biotite rhyolite :—

This rock is generally recognized in the contact zone of biotite-granite porphyry and Miyai groups. It is very weak to weathering. When fresh, it is greenish gray and turns to brownish as it decomposes. With the naked eye, phenocrysts of quartz, feldspar and biotite in dense groundmass are recognized. This rock reveals gradual transition to biotite-granite porphyry and injects in Miyai groups giving a slight contact-metamorphism. The typical distributions of radioactivity near contact are given in Fig. 4.

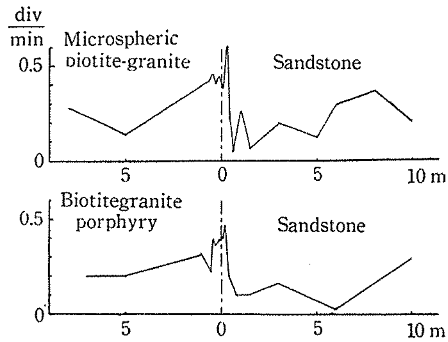

Fig. 4. Radioactive profiles. (Kumano)

Uno

Biotite granite :—

At this locality, main igneous rock is biotite granite. This is grayish white in color, and medium- to coarse-grained. The principal components are orthoclase, plagioclase, quartz and biotite. Here, the rock is very decomposed. At Matsuo, lamprophyre is recognized in granite. These rocks intruded into upper Paleozoic formations.

Upper Paleozoic formations :—

There are slate and alternation of slate and sandy-slate. Slate is grayish black in color and hard. Sandy-slate is about 4 cm in thickness. These rocks are metamorphosed to hornfels and mica-slate by intrusion of granite.

The results are shown in Fig. 5.

Matsuyama

In this district, the samples are collected from the contact of Paleozoic sediments with hornblende-biotite granite.

Paleozoic sediments :—

This rock consists of sandstone in the lower part, and alternating layers of sandstone and shale in the upper, conformably covering the former. This rock is metamorphosed by hornblende-biotite granite to mica-schist or hornfels of which color is blackish gray to grayish black.

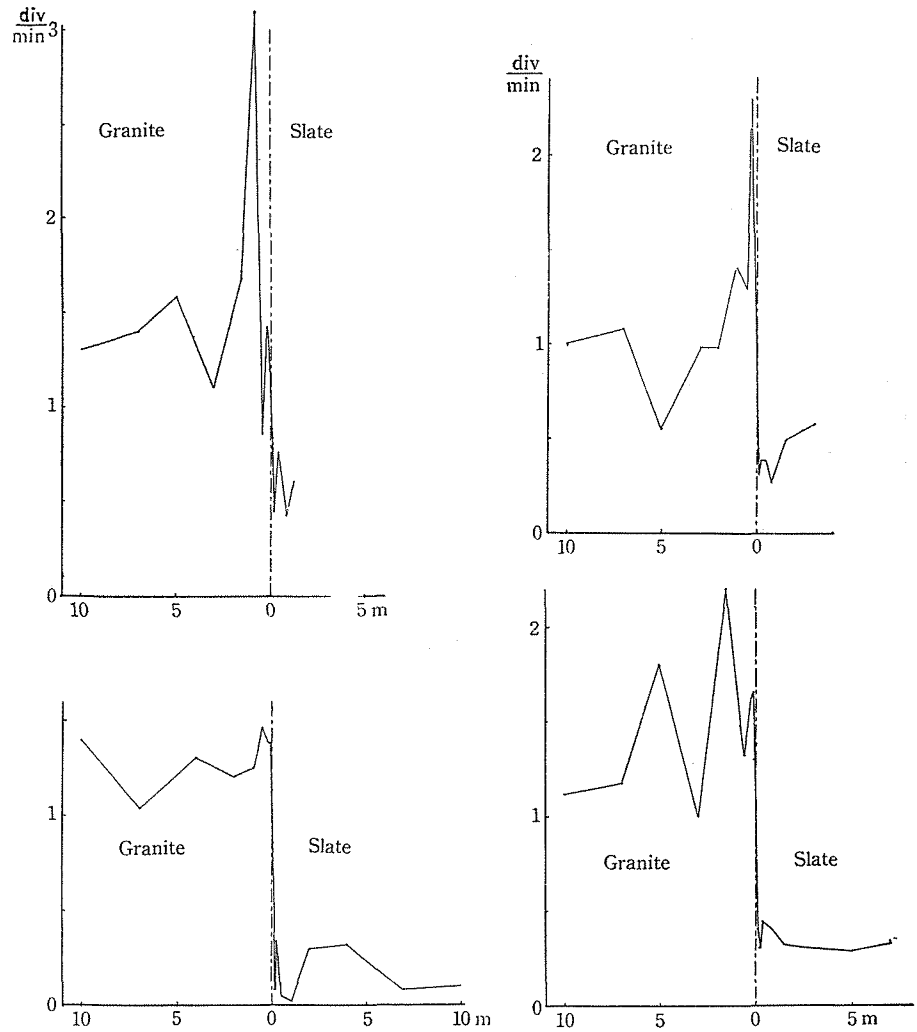

Fig. 5. Radioactive profiles. (Uno)

Hornblende-biotite granite :—

This rock is grayish white in color. The principal components are quartz, plagioclase, orthoclase, biotite and hornblende. This intrudes into Paleozoic sediments and metamorphosed it. The rock shows gradual transition to biotite-granite.

The radioactive profile across contact is shown in Fig. 6.

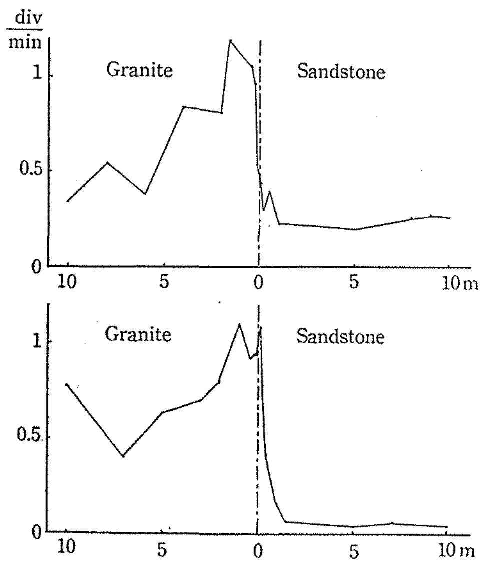

Fig. 6. Radioactive profiles. (Matsuyama)

Mt. Takatsuki

In this district, the samples are collected from the contact of biotite-granite and Cretaceoos formations.

Biottite-granite :—

Biotite-granite intrudes into the Cretaceous formations, Torinosu and Shimonto series. Near the margin of the granite mass are usually seen fine-grained leucocratic, aplitic granites, some of which contain sporadically tourmaline at the Nameritoko.

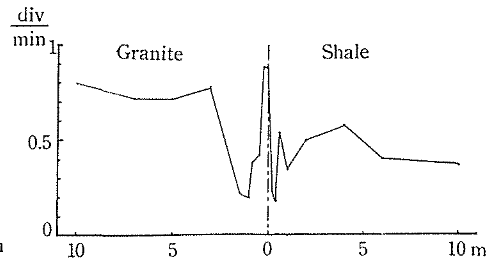

Fig. 7. Radioactive profile. (Mt. Takatsuki)

Cretaceous formations :—

Cretaceous formations consist of green to gray shale and sandstone with conglomerate. The shale is sometimes sandy and sometimes nodulous. The sandstone is usually massive. About contact zone, it is metamorphosed to hornfels.

In Fig. 7 is shown the radioactivity distribution across igneous contacts.

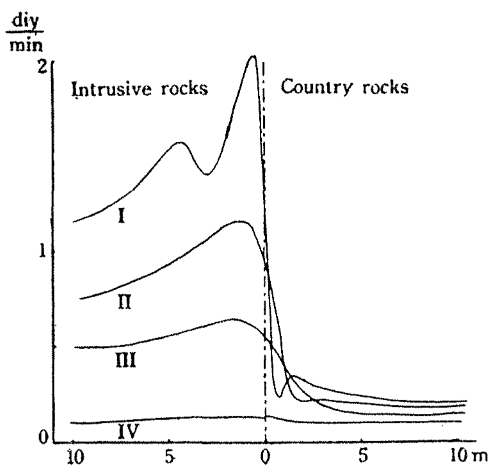

Fig. 8. Types of radioactivity distributions across igneous contacts.

Discussion of the Results

The writers have ever reported that the profile curves of radioactivity across igneous contacts may be classified into several types[4]. In Fig. 8, the curves, representing each type, are schematically drawn. This suggests that, at the later stage in solidification of granite magma, whether it is wholly or partially in a melting state at the margin of the intrusive body, distribution of radioactivity depends upon the migrating power of radioactive elements. Migration occurred not only of radioactive elements but also of the like elements. This is backed by the following. For example, the distribution of Rubidium found by F. A. HENSON[2] bears a striking resemblance to the distribution of radioactive elements found at Tachiki[4] and Uno. Considering these relations, these distribution may be inferred to show the mode of migration of volatile matter. The fact that several types were found in radioactivity distribution implies that existence of differences in the grade of melting of invading masses, i.e., whole or partial melting or at the extremity non-melting states, metasomatism in solid state.

Lastly, the authors are expecting kind suggestions on the petrological evidences which may be considered to have any connection with the radioactivity distribution, especially from those who are engaged in the investigation of geology of the localities above mentioned.

Acknowledgment

The authors are greatly indebted to the kind guidance by Prof. N. KUMAGAI. This investigation has been partly supported by the financial aid of the Scientific Research Expenditure of the Ministry of Education.

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