The Radioactivity of Rocks and Minerals Studied with Nuclear Emulsion (VI) : Radioactivity of some Japanese Liparites

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Radioactivity of some Japanese Liparites

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Abstract

Radioactivity of some of Japanese liparites is measured by means of nuclear emulsion technique. As the result, the radioactive elements in liparite, as in granite, seem to be of later crystallization. Characteristic distribution of radioactive elements in acid volcanic rocks has been studied on some of Japanese liparite samples, and the results are reported.

Introduction

It is said that the radioactivity of igneous rock increases with the acidity of the rock, and therefore liparite must be of the highest order in radioactivity among all the volcanic rocks. Distribution of radioactive elements in igneous rocks shows no great difference between the plutonic and the volcanic series. In this paper the present author aims at mere preliminary results concerning the radioactivities of acid volcanic rocks. Up to the present time the radioactive investigation of volcanic rocks has been rather neglected—due to the fact that granite has minute radioactive minerals as various accessory species, while liparite lacks them. The behavior of radioactive materials in acid volcanic rocks indicates distribution of higher concentration in the residual of fine crystalline part of those rocks than in the porphyritic large crystals. That is to say, the radioactivity must get more condensed in the residual liquid which any "Magma" leaves behind.

The present author intends to avoid the word "Magma", but here he understands by it the rock-forming raw materials. He finds no reason to believe that any material in liparite is derived directly from the primordial "Magma" The discussion thereupon will be presented in some later papers.

Radioactivity of some Japanese liparites

The measurement of radioactivity was carried out by contact autoradiographic method. Generally, the alpha track number per unit area on the uncovered thin section of liparite during unit time was carefully counted under the microscope. The exposure time extended, for example, 311 days or 115 days, as the detectable radioactivity of principal rock-forming mineral is very feeble.

In these cases, a special care was taken to keep the latent image of alpha tracks in the nuclear emulsion unfading during the long exposure time. The blank tracks ejected from the radioactive materials in the plate glass or emulsion itself, though only of minute amount, have been accumulated during such a long time. The photo plates used in this study were the autoradiographic photo plate (15 microns in thickness) manufactured by Fuji Photo Co. Ltd.

If it is tacitly assumed that radioactive equilibrium exists in these liparites, and as the alpha permeability (ψ) of these rocks is 4.74 and the density of them 2.7, the following values result from EVANS and GOODMAN's (1941)[1] and YAGODA's (1949)[2] data:

Granitic rocks	α/mg/hour	2.2 ± 0.2
	U ppm	3.0 ± 0.3
	Th ppm	13 ± 2.0

$T_\alpha=\psi\ (25.73\ U+7.80\ Th)$

$T_\alpha=0.000848$ for liparite

The surface alpha radioactivity of liparite can be given from the above quoted data as $T_\alpha=0.000282\fallingdotseq0.0003$ for rocks containing 1 ppm U and the corresponding amount of Th. In other words, the powdered rock activity emitting 1 alpha per milligram per hour corresponds to $T_\alpha=0.0004$.

The radioactive values of liparites are shown in Table 1. Here rocks of similar type and same mass have the same order of radioactivity, for example, in Nishinomiya liparite (a fresh rock sample) its radioactivity varies from $T_\alpha=0.0005$ to 0.0007, and in Tsuyama rocks of the flow breccia of liparite from 0.0003 to 0.0004. But the glassy part of liparite tuff of Sanda amounts to 0.0019, and more elaborate results will soon follow. Rock like Wada Pass obsidian (Nagano Prefecture) is high in radioactivity; and this seems to be due to its intrusion into the Tertiary granite correlatable to the Kinbusan granite (Yamanashi Prefecture).

By the way, the radioactive anomaly of acid volcanic rocks is seen only in the tuffaceous or glassy rocks, but not in the fresh common liparite.

The alpha track counting on the photo plate was performed by scanning it on the microscopic stage, traversing about 10 mm long at 0.11 mm wide. The radioactivity generally seems to be more homogeneous in liparite than in granite, the absence of minute radioactive minerals such as thorite and monazite abundant in certain granitic rocks seems to give this difference.

Radioactivity of liparitic feldspar

The radioactivity of feldspar as a principal constituent is very feeble and can

Table 1. Radioactivity of Liparite.

Rock Mass	Locality	Rocks	Radioactivity (T_α)
Nishinomiya	Arima	Liparite	0.0005
» 1037		»	0.0005, 0.0006
»	Arima	» (porphyritic)	0.0006
» 1046		»	0.0006
» 1042		»	0.0006
» 1039		»	0.0007
»	Shioze, Amako Bridge	»	0.0007
»	Sanda	Liparite tuff	0.0019
Western part of Hyogo Pref. & Tsuyama	Chigusa vil., S. Takanosu, Hyogo Pref.	Liparite	0.0003
»	S. W. Tsuyama	Flow breccia of liparite	0.0002 0.0003 (2) * 0.0004 (3) *
»	Kanzaki County, Hyogo Pref.	Liparite	0.0005
»	Chigusa vil., E. Tokayano, Hyogo Pref.	Liparite	0.0006
»	Ikuno	Liparite tuff breccia	0.0010 0.0005
»	Tsutazawa vil., Shirakuchi Pass, Hyogo Pref.	Perlite	0.0010
Kinosaki Hyogo Pref	Kinosaki Hiradake-dani	Glassy perlite	0.0003, 0.0002
»	Kinosaki	Chalcedonic liparite	0.0004, 0.0002
»	Izushi	Pitchstone	0.0005
»	Tango	Mn. Liparite	0.0009
Muro and Nijo Volcanoes	Nijo-san	Mica andesite	0.0001
»	»	Garnet dacite	0.0003
»	Narahara vil., Uda County, Nara Pref.	Rhyo-dacite	0.0001
»	Shimotaro-Mitohoshi, Uda County	Dacite	0.0003
»	Tsugeno vil., Uda County	Rhyo-dacite	0.0003 (3) * 0.0004
Miscellaneous	Shionomisaki, Wakayama Pref.	Micro granophyre	0.0003
»	Nirasaki-Shichiriiwa, Soboishi vil., Yamanashi Pref.	Liparite	0.0003
»	Kaga Hakusan	Spherulitic liparite	0.0005, 0.0007
»	Wada Pass, Nagano Pref.	Obsidian	0.0022, 0.0018

( ) * number of samples

only be detected by long time autoradiographic exposure. The size of most feldspar under the microscope is quite unfavorable for the counting of the track number, the microscopic observation demands much carefull and tedious calibration.

The adjustment, however, needs double processes: First, under the low power objective lens, we must see if there are not radioactive anomalies and inclusions. Secondly, if the radioactivity of feldspar is found to be homogeneous, then we must turn to the high power lens. The field here in this case extends about 1.8×0.01 mm^2. The average value of the feldspar radioactivity must, at least for several fields, be measured by sliding the thin section. The adjustment of the emulsion with the rock thin section is helped by the three cross marks recorded on both of them. First the plate glass is pasted together directly with the slide glass, separating the emulsion from the rock thin section with a distance of some 2 mm (the thickness of two glass plates). Naked eye adjustment will soon attain to so close a coincidence, that even microscopic examination finds only small deviation of less than some 30 microns.

In emulsions exposed even 311 days, the alpha track number in one microscopic field counts only from 0 to 2 for quartz and from 3 to 10 for plagioclase feldspar. Besides, the blank tracks must be taken into consideration, especially when the emulsions are not fresh and multiple star tracks are found.

The fresh liparitic feldspar has the radioactive order of $T_\alpha=0.0002$ in case of sodic plagioclase and orthoclase. In sericitized feldspar the radioactivity is still higher. The altered feldspar replaced with the dusty earthy material which is composed of micaceous brown or yellowish material has much higher radioactivity.

The prophyritic quartz of liparite shows feeble radioactivity. ($T_\alpha=0.0001$ or less)

Table 2. Radioactivity of feldspar.

Locality	Rocks	Feldspar	Radioactivity (T_α)
Arima	Liparite	Zonal plagioclase	0.0002
〃	Porphyritic liparite	Fresh plagioclase	0.0002
Nishinomiya 1046	Liparite	Yellow altered plagioclase	0.0003
Tsuyama	Tuff breccia of liparite	Ovoidal sericitic plagioclase	0.0006
Nishinomiya 1037	Liparite	Altered dusty yellow plagioclase	0.0013
〃 1042	Liparite	Plagioclase with pale yellow core	0.0005
		Plagioclase with dusty brown core	0.0012, 0.0020
〃 1037	Liparite	Fresh orthoclase	0.0002

Radioactivity of colored minerals of liparite

The colored minerals of liparite show high radioactivity, but do not contain minute radioactive minerals as granitic biotite does. Table 3 shows the radioactivity of colored minerals such as biotite, hornblende and chlorite, some of which are higher in radioactivity than that of altered plagioclase of liparite. Even in all these principal rock-forming minerals, the radioactivity appears to be heterogeneously distributed.

The spherulitic liparite of Hakusan contains epidote-like radioactive minerals which are of radioactive heterogeneity too, and the brownish part with high birefringence has higher radioactivity than the transparent pale bluish part with low birefringence. This may be due to the heterogeneity of chemical composition, for instance, to the different amount of rare earth and so on.

Table 3. Radioactivity of colored minerals.

Locality	Rocks	Colored Mineral	Radioactivity (T_α)
Nishinomiya 1037	Liparite	Kaolinized biotite	0.0026, 0.0036
Arima	Liparite	Chloritized biotite	0.0003
〃	〃	Chlorite and epidote	0.0007
〃	Porphyritic liparite	Biotite clot	0.0027
Hase vil., Hyogo Pref.	Liparite	Biotite	0.0011, 0.0004
Tsuyama	Tuff breccia of liparite	Green hornblende	0.0005, 0.0002
Hakusan	Spherulitic liparite	Brown epidote	0.0134～0.0067
〃	〃	Pale bluish epidote	0.0018

Radioactivity of liparitic ground mass

The radioactive materials in igneous rocks are contained in the main rock-forming mineral and glassy matrix. Even in granitic rocks, the common accessory minerals,

Table 4. Radioactivity of liparitic groundmass.

Locality	Rocks	Part of the rocks	Radioactivity (T_α)	Total activity
Nishinomiya 1037	Liparite	Groundmass	0.0007	0.0006
Arima	Liparite	Groundmass	0.0005	0.0005
Sanda	Tuff	Glassy groundmass	0.0025, 0.0016	0.0019
Arima	Porphyritic liparite	Groundmass	0.0008	0.0006
Ikuno	Liparite	Groundmass	0.0017	0.0010
Wada Pass	Obsidian	Glass	0.0022	—
Akaho	Tuff breccia	Groundmass	0.0008, 0.0011	0.0004
Tsuyama	Tuff breccia	Glass	0.0009, 0.0015	0.0004
Tsuyama	〃	Clouded Matrix	0.0005, 0.0006	0.0003
Hakusan	Spherulitic liparite	Matrix	0.0009	0.0007

like zircon, sphene and so on, occupy less than 20 percent of the total radioactivity in the rocks, and liparite has no such minerals. Feldspar, colored minerals and glassy matrix of liparite are the major source of radioactive elements, and especially the last one is petrogenetically most interesting. (See Table 4)

Radioactivity of minute accessory minerals in liparite

Here, we must alude to the mildly radioactive common accessories: zircon in liparite. They are all transparent and feeble in radioactivity. (See Table 5) In volcanic rocks, especially in liparite, these accessories are contained in matrix or glassy part. The highly radioactive minerals common in granite, such as uranothorite or uraninite, cannot be seen in liparite so far. The absence of zircon in biotite and feldspar, but its presence only in matrix or glassy part, seems to tell us later origin of liparitic zircon.

Table 5. Radioactivity of minute accessory minerals.

Locality	Mineral	Position in the thin section	Radioactivity (T_α)
Nishinomiya 1037	Zircon	Matrix	0.2046
	"	"	0.4255
	"	"	0.0617
	"	"	0.0482
	"	"	0.1157
	"	"	0.1215
	"	"	0.2490
Tango 489	"	"	0.1956
Sanda	"	Quartz	0.0097
Nishinomiya 1042	"	Matrix	0.5940
	"	"	0.0755
Shionomisaki	Brown zircon	"	0.0165

Summary

1. Radioactive behavior of liparite differs from that of granite.

2. In liparite, transparent zircons of feeble radioactivity are contained only in the matrix.

3. Matrix or glassy part of liparite shows high radioactivity.

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