16. Composition of the Main Chemical Components in the Rocks from Hotoke-iwa Volcanic Body of Mt. Asama.

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1. Introduction

The Hotoke-iwa volcanic body which builds up a part of the volcano of Asama is composed of dacitic rocks including obsidian, and is in distinct contrast to the main body of Asama composed of andesitic rocks. TSUYA[1,2] has considered the period of its activity to be between that of the old somma (Kurohu-yama) and that of the young somma (Mae-kake-yama). Although this volcanic body was buried almost entirely through the subsequent activities of Asama, TSUYA[2] has suggested that the framework of present topography of the eastern part of Asama was determined by the shape of this volcanic body.

Chemical composition of the rocks of Asama volcano including Hotoke-iwa has been reported by TSUYA[1,2] and by IWASAKI[3]. As to the rocks of Hotoke-iwa, however, only four analyses have been made. For the consideration of the genetic relationships between the andesites of the main body of Asama and the dacites of this body, it seemed necessary to examine more samples.

In this paper, the results of analyses for main chemical components of newly collected twelve specimens and the consideration about the small compositional variation are reported. Comparison of chemical composition of these rocks with that of andesites from the main body of Asama and discussion about the relationships between these two

1) H. TSUYA, Bull. Earthq. Res. Inst., **11** (1933), 575.
2) H. TSUYA, Geography (Tirigaku), **2** (1934), 1265 and 1479 (in Japanese).
3) I. IWASAKI, J. Chem. Soc. Japan, Pure Chem. Sec., **57** (1936), 1324 (in Japanese).

groups will be presented after the completion of analyses of andesites in the near future.

2. Specimens

Localities where specimens were collected are shown in Fig. 1. Specimens 211–215 are biotite-hornblende-bearing augite-hypersthene-dacite, and were collected at the lower cliff of Hotoke-iwa (Midagazyō-iwa) at a height of *ca.* 1900 m above the sea. Specimen 211 was taken from the exposed lowermost part of the cliff, specimen 212 at a point *ca.* 15 m above the place of 211, and so on to specimen 215 in the order of the increasing height. The last came from the middle part of the cliff. Specimens 221 and 222 are hypersthene-dacite collected near the western summit of Ko-asamayama, which has been regarded by TSUYA[1,2] as a parasitic cone of Hotoke-iwa volcanic body. Specimen 231 is hypersthene-dacite from an east-faced cliff situated *ca.* 150 m
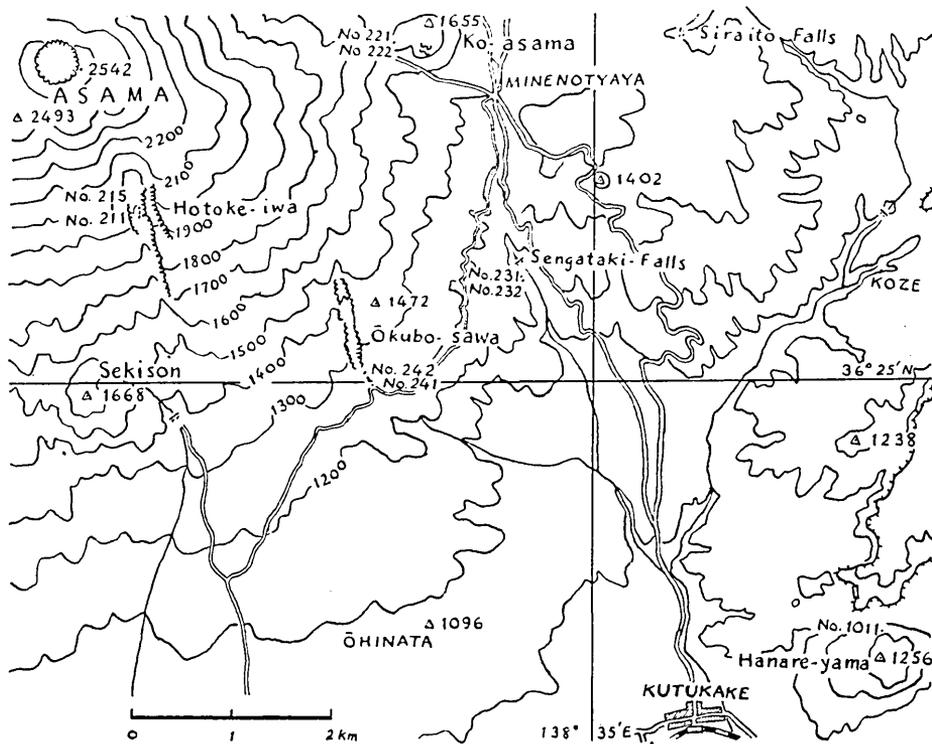

Fig. 1. Locality Map of the Specimens.

south of the Sengataki falls. In the lowermost part of this cliff, the rock, represented here by specimen 232, occurs as a kind of obsidian of hypersthene-dacite. Specimens 241 and 242A were taken from a cliff facing south-west of the dry valley of Ōkubo-sawa at a height of *ca.* 1300 m above the sea, and are obsidian of hypersthene-dacite. Specimen 242B is a globular inclusion found in specimen 242. Specimen 1011 is not of Hotoke-iwa volcanic body, but of a small volcanic body, named Hanareyama, which stands 10 km southeast of Asama, and was taken from a quarry on its northern flank. Since Hanareyama volcanic body is composed also of dacitic rocks, this specimen of augite-hypersthene-dacite was analysed for the purpose of comparison.

Features of these specimens are given in Table 1. Taking these characteristics into account, it seems to be convenient to group these rocks as follows:

<pre>
Dacites of   ⌠Western Dacites
  Hotoke-iwa   ⎨   ⌠Ko-asamayama Dacites⌡Eastern
  volcanic body   ⎩Eastern Rocks⎨   ⎬ Dacites
                                 ⎩⌠Non-Ko-asama Dacites⌡
                                  ⎩Obsidians
</pre>

Table 1. Features of Specimens.

Specimen No.	Locality	Features	Phenocryst Amount*
211	Hotoke-iwa	Grey-black, with grey band.	M
212	〃	Grey-black.	M
213	〃	Grey, with grey-black band.	M
214	〃	Grey-black and dark reddish brown.	M
215	〃	Grey, with spots of black glass.	M
221	Ko-asama	Grey, without banding.	L
222	〃	Banding of grey-black and brownish grey parts.	L
231	near Sengataki	〃　　　　　〃	L
232	〃	Black obsidian.	L
241	Ōkubo-sawa	Grey-black translucent obsidian.	L
242 A	〃	Black obsidian.	L
242 B	〃	Included in 242A, reddish brown, with lamprophyric texture of " basic inclusion "[4].	M
1011	Hanareyama	Banding of black and grey parts.	M–A

* A: >1/3, M: 1/3∼1/5, L: <1/5 of the rock.

4) H. WILLIAMS, F. J. TURNER, and C. M. GILBERT, *Petrography* (*Freeman*, 1954).

Mean modal compositions of Western Dacites and Eastern Rocks are presented in Table 2. These values are the arithmetic mean obtained by volumetry of several sections. Each specimen was represented by one section.

Table 2. Modal Compositions (in Vol. %).

	Glass	Plagioclase	Hypersthene	Augite	Iron Ore
Western Dacites	76.1	19.4	2.9	0.9	0.5
Eastern Rocks	91.3	8.0	0.5	0.1	0.3

Approximate chemical compositions of phenocryst minerals separated from the mixed powder sample of Western Dacites are given in Table 3. Composition of pyroxenes was estimated from optical characters[5], and that of plagioclase was determined by the chemical analysis of Ca, Na, and K.

Table 3. Characters of Phenocrysts of Western Dacites.

	Optical Characters*	Estimated Composition	Mode (in Wt. %)**
Plagioclase	——	$An_{55}Ab_{44}Or_1$	20.7
Hypersthene	$\alpha=1.682$, $\gamma=1.714$, $2V=(-)57°\sim60°$	$En_{62}Fs_{38}$	3.9
Augite	$\alpha=1.683$, $\gamma=1.716$, $2V=(+)51°\sim52°$	$Wo_{42}En_{41}Fs_{17}$	1.2
Iron ore	——	——	1.2

  * Observed by Mr. I. Kushiro.
 ** Bulk density=2.52.

3. Analytical Methods

Chemical analysis was carried out mainly using the rapid methods described by Shapiro and Brannock[6] and by Riley[7]. SiO_2, TiO_2, Al_2O_3, and total Fe were determined spectrophotometrically after Shapiro and Brannock, and MnO and P_2O_5 after Riley. Determination of CaO[8] and MgO was made by the visual complexometric titration after the removal of Fe, Ti, and Al using urotropin[9]. Na_2O and K_2O were deter-

5) H. H. Hess, Am. Mineralogist, **34** (1949), 621.
6) L. Shapiro and W. W. Brannock, U. S. Geol. Surv. Bull., **1036** C (1956).
7) J. P. Riley, Anal. Chim. Acta, **19** (1958), 413.
8) J. Patton and W. Reeder, Anal. Chem., **28** (1956), 1026.
9) V. Patrovský and M. Huka, Collection Czechoslov. Chem. Communs., **21** (1956), 866.

mined by the flame photometric method. Loss on ignition was substituted for H_2O content, correction being made for the oxidation of ferrous iron. FeO was determined after conventional method.

4. Results of Analyses

In Table 4 are given results of chemical analyses. Variation dia-

Table 4. Chemical Compositions of Specimens.

Specimen	211	212	213	214	215	221
SiO_2	69.3	70.0	69.4	69.3	68.8	73.1
TiO_2	0.62	0.58	0.60	0.71	0.66	0.49
Al_2O_3	15.1	15.1	15.0	15.0	15.7	14.3
Fe_2O_3	1.57	1.09	1.39	1.43	2.18	0.97
FeO	1.63	1.71	1.56	1.77	1.08	1.24
MnO	0.06	0.06	0.07	0.06	0.06	0.06
MgO	0.98	0.90	0.73	0.95	1.08	0.80
CaO	3.63	3.33	3.51	3.54	3.86	2.31
Na_2O	3.98	3.94	4.07	4.28	3.90	4.12
K_2O	1.83	1.78	1.88	2.13	1.85	2.06
H_2O	0.64	0.60	0.61	0.66	0.87	0.57
P_2O_5	0.12	0.12	0.12	0.14	0.13	0.03
Sum	99.5	99.2	98.9	100.0	100.2	100.1
Fe°*	3.38	3.01	3.12	3.38	3.44	2.37
Q	29.7	31.4	29.8	27.3	29.5	34.8
C	0.2	0.9	0.2	—	0.6	1.1
Or	10.8	10.5	11.1	12.6	10.9	12.1
Ab	33.7	33.3	33.4	36.2	33.0	34.9
An	17.3	15.7	16.6	15.4	18.3	11.3
Wo	—	—	—	0.52	—	—
En	2.44	2.25	1.82	2.37	2.69	1.99
Fs	0.78	1.39	0.86	0.99	—	0.78
Mt	2.27	1.58	2.01	2.08	1.78	1.41
Hm	—	—	—	—	0.94	—
Il	1.18	1.10	1.14	1.35	1.26	0.93
Ap	0.28	0.28	0.28	0.32	0.30	0.07
SI**10)	9.6	9.4	7.4	8.3	10.5	8.6

* Total Fe as Fe_2O_3.·   ** $MgO \times 100/Fe° + MgO + Na_2O + K_2O$.   (to be continued)

10) H. KUNO, *Volcanoes and Volcanic Rocks* (Iwanami, 1953, in Japanese), p. 178.

(continued)

Specimen	222	231	232	241	242 A	242 B	1011
SiO_2	72.9	73.0	72.7	73.7	73.0	58.9	68.2
TiO_2	0.48	0.53	0.51	0.47	0.47	0.94	0.68
Al_2O_3	14.3	14.2	14.3	14.2	14.1	16.8	15.5
Fe_2O_3	1.81	1.42	0.42	0.39	0.65	4.62	1.37
FeO	0.57	0.97	1.79	1.62	1.58	2.46	2.11
MnO	0.06	0.06	0.06	0.06	0.06	0.10	0.07
MgO	0.72	0.64	0.60	0.63	0.58	3.48	1.34
CaO	2.53	2.62	2.80	2.49	2.59	7.49	4.38
Na_2O	4.12	4.32	4.19	4.47	4.12	2.97	3.75
K_2O	2.04	2.33	2.33	2.30	2.07	1.00	1.70
H_2O	0.55	0.30	0.38	0.42	0.37	1.14	0.56
P_2O_5	0.08	0.08	0.09	0.09	0.09	0.17	0.12
Sum	100.2	100.5	100.2	100.8	99.7	100.1	99.8
$Fe°$	2.45	2.50	2.39	2.19	2.38	7.55	3.75
Q	35.0	32.6	31.7	31.9	34.1	18.4	28.1
C	0.9	—	—	0.0	0.6	—	—
Or	12.0	13.8	13.8	13.6	12.2	5.9	10.0
Ab	34.9	36.5	35.4	37.8	34.9	25.1	31.7
An	12.0	12.4	13.3	11.8	12.3	29.6	20.4
Wo	—	0.05	0.01	—	—	2.68	0.21
En	1.80	1.60	1.50	1.57	1.45	8.68	3 34
Fs	—	—	2.20	2.02	1.69	—	1.75
Mt	0.63	1.78	0.60	0.56	0.95	5.51	1.99
Hm	1.37	0.19	—	—	—	0.81	—
Il	0.91	1.00	0.97	0.90	0.90	1.79	1.29
Ap	0.18	0.18	0.20	0.20	0.20	0.39	0.28
SI	7.8	6.5	6.3	6.6	6.2	23.2	12.7

gram prepared from these data is shown as Fig. 2. Mean composition of each group of rocks is presented in Table 5.

5. Discussion

i) *Relation between Chemical Composition and Macroscopic Feature of Rocks.*

As may be recognized from Tables 1, 4, and 5, or Fig. 2, there seems to be no systematic difference in chemical composition between

Table 5. Mean Composition of Each Group of Rocks.

Group	I	II	III	IV	V	VI
SiO_2	69.4	73.1	73.0	73.1	73.0	73.1
TiO_2	0.63	0.49	0.50	0.48	0.49	0.50
Al_2O_3	15.2	14.3	14.3	14.2	14.3	14.2
Fe_2O_3	1.53	0.95	1.40	0.49	1.39	0.72
FeO	1.55	1.30	0.93	1.66	0.91	1.49
MnO	0.06	0.06	0.06	0.06	0.06	0.06
MgO	0.93	0.66	0.72	0.60	0.76	0.61
CaO	3.57	2.51	2.49	2.62	2.42	2.63
Na_2O	4.03	4.23	4.19	4.26	4.12	4.28
K_2O	1.89	2.19	2.14	2.23	2.05	2.26
H_2O	0.68	0.43	0.47	0.39	0.56	0.37
P_2O_5	0.13	0.08	0.06	0.09	0.06	0.09
Sum	99.6	100.3	100.3	100.2	100.1	100.3
Fe°	3.27	2.38	2.44	2.32	2.41	2.37

I : Western Dacites. III: Eastern Dacites. V : Ko-asama Dacites.
II : Eastern Rocks. IV: Eastern Obsidians. VI: Non-Ko-asama Rocks.

obsidians and non-obsidians in Eastern Rocks, and also between grey rocks and grey-black rocks in Western Dacites.

ii) *Comparison of Chemical Composition of Western Dacites and Eastern Rocks.*

It is noted from the results given in Tables 4 and 5 that there is some variation in chemical composition among specimens. Especially the difference between Western Dacites and Eastern Rocks is fairly marked.

To interpret this difference as a function of the content of phenocryst minerals, the mean composition of groundmass of Western Dacites is estimated for seven components, *i.e.*, SiO_2, Al_2O_3, total Fe as Fe_2O_3, MgO, CaO, Na_2O, and K_2O, TiO_2 being added to total Fe.

Comparing this estimated groundmass composition and the bulk composition of Western Dacites with the bulk composition of Eastern Rocks, it appears likely that the composition of the last one is given by mixing the former two (Table 6, and Fig. 3). On the other hand, the trial to explain the composition of Western Dacites as the mixture of Eastern Rocks and the basic inclusion (specimen 242B) was less successful (Fig. 4).

iii) *Interpretation of Compositional Variation among Specimens.*
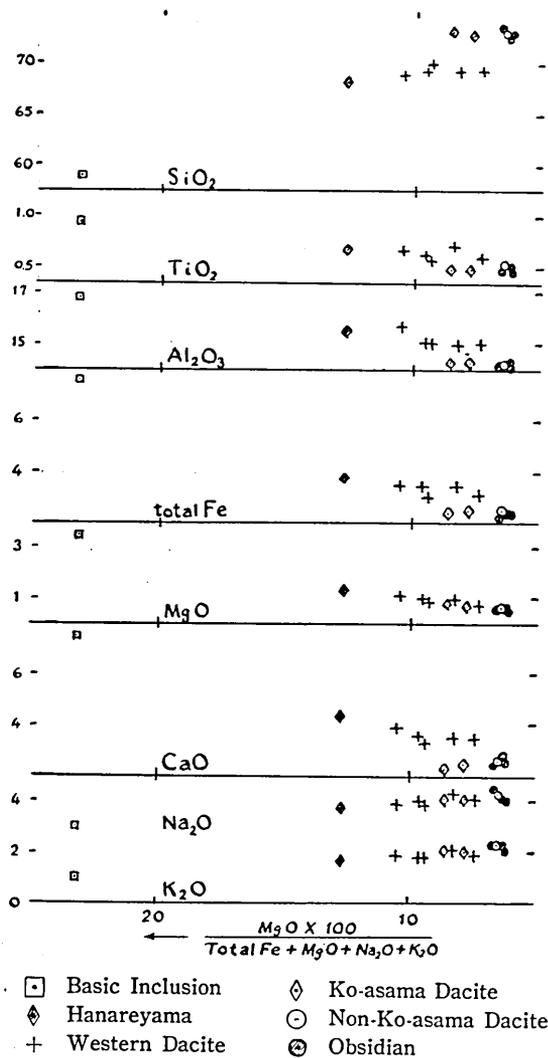Even in a single group of rocks, some heterogeneity is observed.
If one tries to explain this heterogeneity by the difference in the contents of phenocryst minerals, it becomes necessary to vary the relative contents of these minerals. Such a system is too complicated to be analysed graphically. Therefore, another method must be considered.

The phenocryst minerals found in Hotoke-iwa rocks are plagioclase, hypersthene, augite, magnetite, ilmenite, biotite, and hornblende. The last two are found only in minute quantities, and can left out of consideration. Combining magnetite and ilmenite as iron ore, assuming the ratio of augite to hypersthene to be constant, and considering the variation in chemical composition of plagioclase caused by its zonal structure, we have five independent end members, namely, the groundmass of Western Dacites, anorthite, albite (containing a small amount of orthoclase), pyroxene, and iron ore. Now let us examine whether chemical composition of each rock can be explained by the linear combination of those of the above-mentioned five end members (Table 7, system I). Least squares method is employed with the weight factors proportional to the reliabilities of chemical analyses for individual com-

□ Basic Inclusion   ◊ Ko-asama Dacite
◈ Hanareyama   ⊙ Non-Ko-asama Dacite
+ Western Dacite   ⊘ Obsidian

Fig. 2. Variation Diagram.

Table 6. Compositions reduced to Seven Components.

	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$*	MgO	CaO	Na$_2$O	K$_2$O	Sum
I	51.6	22.8	8.36	3.54	9.75	3.96	0.08	100.0
II	70.2	15.4	3.94	0.94	3.61	4.08	1.91	100.0
III	73.2	14.3	2.88	0.66	2.56	4.23	2.20	100.0
IV	76.9	12.7	2.34	0.00	1.39	4.12	2.57	100.0

* including TiO$_2$.

I : Western Dacites, Phenocryst (estimated). II: Western Dacites, Bulk. III: Eastern Rocks, Bulk. IV: Western Dacites, Groundmass (calculated).
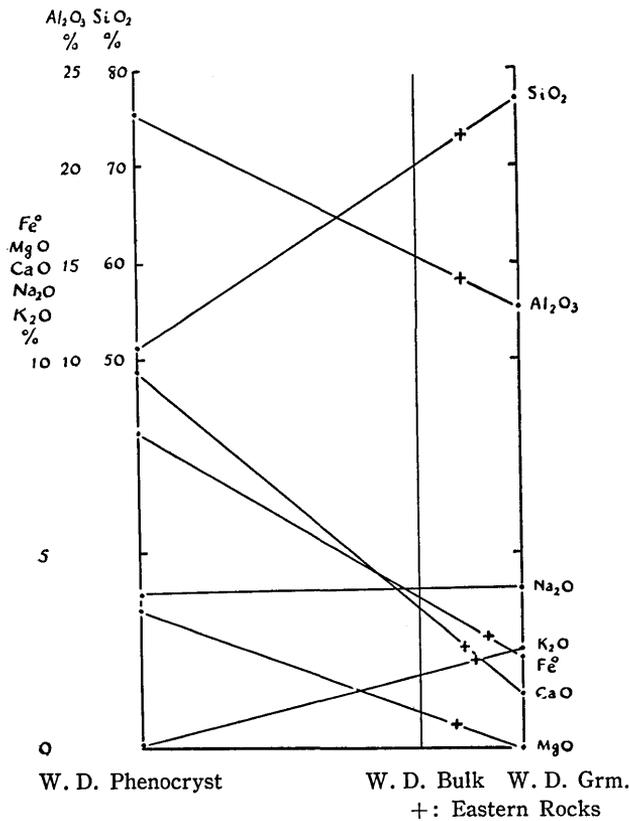

Fig. 3. Mixing Diagram of the system W. D. Phenocryst-W. D. Groundmass.

ponents. Use of this method makes it possible to take the probable analytical error into consideration, this being an important advantage over usual addition-subtraction method.

A set of the contents of the above-mentioned seven (in general, n) components for an individual specimen is regarded here as a vector matrix, $\mathbf{F}$. Let us consider the linear combination of the contents of appropriately assumed end members $\mathbf{F}^1, \mathbf{F}^2, \cdots, \mathbf{F}^m$ (in our case, $m=5$):

$$\mathbf{F}^\circ = \mathbf{F}^1 x_1 + \mathbf{F}^2 x_2 + \cdots + \mathbf{F}^m x_m , \qquad \cdots (1)$$

here m must be smaller than $n-1$, n being number of components, since $\sum f_j \equiv 100$.

Introducing the 7×7 (in general, $n \times n$) diagonal matrix $\mathbf{P}$ of the weight factor p_{jj} which is inversely proportional to the square of the standard deviation for each component if available, or its estimated one
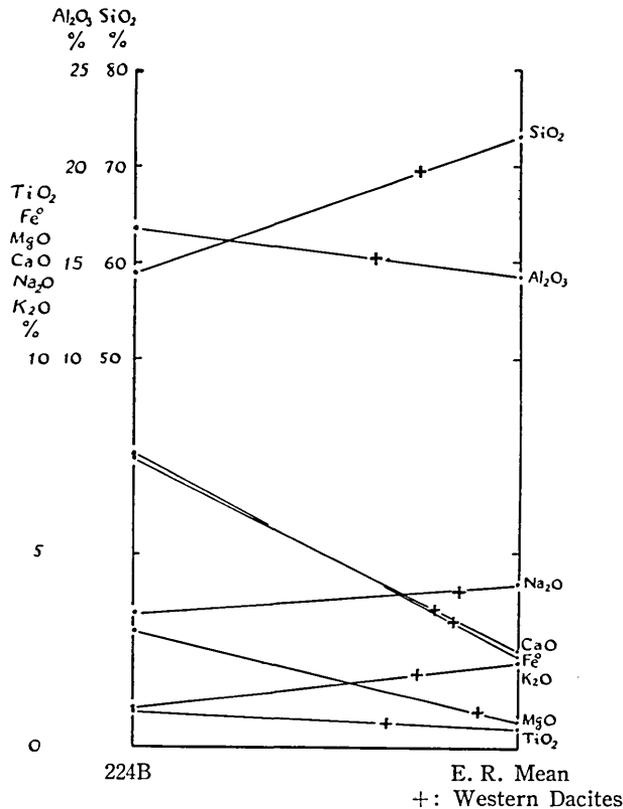

Fig. 4. Mixing Diagram of the system Basic Inclusion-Eastern Rocks.

(called here "reliability"), values of $x_1, x_2, \cdots, x_m$ are calculated as they minimize the quantity,

$$\Delta^2 = (\mathbf{F} - \mathbf{F}^\circ)^* \, \mathbf{P} \, (\mathbf{F} - \mathbf{F}^\circ) , \qquad \cdots (2)$$

where $(\mathbf{F} - \mathbf{F}^\circ)^*$ denotes the transpose of $(\mathbf{F} - \mathbf{F}^\circ)$. This criterion of weighted least squares is equivalent to

$$\mathbf{A} \, \mathbf{P} \, (\mathbf{F} - \mathbf{F}^\circ) = 0 , \qquad \cdots (3)$$

where $\mathbf{A}$ is a 5×7 (in general, $m \times n$) matrix and $a_{ij} = \partial f_j^\circ / \partial x_i = f_j^i$, i.e., a_{ij} is equal to the content of j-th component in i-th end member, f_j^i. Then equation (1) is written as

$$\mathbf{F}^\circ = \mathbf{A}^* \, \mathbf{X} , \qquad \cdots (4)$$

where $\mathbf{X}$ is a vector matrix of $x_1, x_2, \cdots, x_m$, and we obtain the normal equations (5) by the substitution of (4) for (3) as follows:

$$\mathbf{A} \, \mathbf{P} \, \mathbf{A}^* \, \mathbf{X} = \mathbf{A} \, \mathbf{P} \, \mathbf{F} . \qquad \cdots (5)$$

Solution of (5) gives a $\mathbf{X}$ vector, in which x_i is the estimated fraction of i-th end member in the vector $\mathbf{F}^\circ$; and $\mathbf{F}^\circ$ can be calculated after (4).

Results of these calculations are given in Table 8. Since iron ore is chosen as one of the end members, $f_{\mathrm{Fe_2O_3}}^\circ$ should be equal to $f_{\mathrm{Fe_2O_3}}^\circ$, i.e., the calculated and the observed contents of $\mathrm{Fe_2O_3}$ agree necessarily. Therefore, this serves only as a check of calculation.

Table 7. Compositions of End Members and Estimated
Reliability for Each Component

End Members	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	Sum	System I	System II
Ground-mass	76.9	12.7	2.34	0.0	1.39	4.12	2.57	100.0	*	*
Albite	68.7	19.4	0.0	0.0	0.0	11.65	0.24	100.0	*	
Anorthite	43.2	36.6	0.0	0.0	20.2	0.0	0.0	100.0	*	
Pyroxene	52.2	0.0	22.9	20.0	4.90	0.0	0.0	100.0	*	*
Iron ore	0.0	0.0	100.0	0.0	0.0	0.0	0.0	100.0	*	*
$Or_{30}Ab_{70}$	67.5	19.1	0.0	0.0	0.0	8.3	5.1	100.0		*
$Ab_{43}An_{57}$	54.3	29.1	0.0	0.0	11.5	5.1	0.0	100.0		*
Reliabilities	0.3	0.2	0.03	0.04	0.03	0.04	0.04			

Table 8. Results of the Least Squares Approximation.

| | | f_j | | | | | | | Sum | $x_i\dagger$ | | | | |
		SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	MgO	CaO	Na$_2$O	K$_2$O	Sum	G	F(1)	F(2)	P	O
211	F	70.0	15.3	4.05	0.99	3.67	4.03	1.85	100.0					
	F°(I)	70.0	15.4	4.05	1.00	3.66	4.04	1.90	100.0	73.0	8.86	11.96	4.98	1.20
212	F	71.0	15.3	3.64	0.91	3.38	4.00	1.80	100.0					
	F°(I)	70.6	15.0	3.63	0.92	3.41	4.06	1.97	99.6	75.5	8.14	10.52	4.60	0.82
213	F	70.6	15.3	3.78	0.74	3.57	4.14	1.91	100.0					
	F°(I)	70.5	15.5	3.78	0.75	3.56	4.13	1.93	100.1	74.4	9.21	11.64	3.74	1.18
214	F	69.8	15.1	4.12	0.96	3.56	4.31	2.14	100.0					
	F°(I)	70.5	15.5	4.12	0.94	3.53	4.22	1.90	100.6	72.6	10.58	11.37	4.71	1.34
215	F	69.3	15.8	4.13	1.09	3.89	3.93	1.86	100.0					
	F°(I)	69.4	15.6	4.12	1.08	3.90	3.95	1.86	99.8	71.5	8.55	13.09	5.42	1.21
221	F	73.4	14.4	2.87	0.80	2.32	4.14	2.07	100.0					
	F°(I)	73.2	13.7	2.87	0.78	2.35	4.20	2.18	99.3	84.1	6.35	4.91	3.91	-0.01
	F°(II)	73.3	13.7	2.87	0.78	2.38	4.09	2.27	99.4	85.1	1.71	8.73	3.89	-0.01
222	F	73.2	14.4	2.94	0.72	2.54	4.14	2.05	100.0					
	F°(I)	73.0	14.1	2.93	0.72	2.56	4.19	2.16	99.6	83.2	6.50	6.08	3.61	0.16
	F°(II)	73.1	14.0	2.94	0.71	2.58	4.09	2.21	99.7	84.6	0.72	10.70	3.53	0.15
231	F	73.0	14.2	3.02	0.64	2.61	4.31	2.33	100.0					
	F°(I)	73.4	14.3	3.01	0.62	2.59	4.26	2.16	100.3	83.4	7.05	6.37	3.12	0.35
	F°(II)	72.9	14.5	3.02	0.65	2.60	4.30	2.31	100.2	80.2	4.90	11.53	3.23	0.41

(to be continued)

(continued)

	f_j								G	x_i†			
	SiO₂	Al₂O₃	Fe₂O₃	MgO	CaO	Na₂O	K₂O	Sum		F(1)	F(2)	P	O
232 F	72.9	14.3	2.90	0.60	2.80	4.20	2.34	100.0	84.0	5.87	7.30	2.93	0.26
F°(I)	73.3	14.5	2.90	0.59	2.78	4.14	2.17	100.4	81.2	2.75	12.99	3.05	0.30
F°(II)	72.9	14.6	2.90	0.61	2.77	4.23	2.22	100.3					
241 F	73.4	14.1	2.65	0.63	2.48	4.45	2.29	100.0	83.1	8.41	5.74	3.10	0.00
F°(I)	73.8	14.3	2.65	0.62	2.47	4.40	2.16	100.3	80.2	6.34	10.55	3.10	0.05
F°(II)	73.3	14.5	2.65	0.63	2.48	4.37	2.38	100.0					
242A F	73.5	14.2	2.87	0.58	2.61	4.15	2.09	100.0	84.3	6.02	6.44	2.95	0.22
F°(I)	73.2	14.3	2.87	0.59	2.61	4.17	2.18	99.9	85.7	-0.11	11.28	2.87	0.21
F°(II)	73.4	14.1	2.87	0.57	2.63	4.10	2.20	100.3					
Eastern Rocks, Mean F	73.2	14.3	2.88	0.66	2.56	4.23	2.20	100.0	83.7	6.66	6.14	3.27	0.17
F°(I)	73.3	14.2	2.88	0.65	2.56	4.23	2.17	100.0	82.8	2.74	10.96	3.28	0.19
F°(II)	73.2	14.2	2.88	0.66	2.57	4.20	2.27	100.0					
242B F	59.4	17.0	8.56	3.51	7.56	3.00	1.01	100.0	37.3	12.00	30.41	17.67	3.64
F°(I)	59.2	18.2	8.56	3.53	7.52	2.93	0.99	101.0					
1011 F	68.7	15.6	4.46	1.35	4.41	3.78	1.71	100.0	68.3	8.29	15.46	6.83	1.30
F°(I)	68.5	16.0	4.46	1.37	4.39	3.78	1.78	100.2					

† G: Groundmass, F(1): $\begin{cases} \text{Ab (System I)} \\ \text{Or}_{30}\text{Ab}_{70}\text{ (System II)} \end{cases}$, F(2): $\begin{cases} \text{An (System I)} \\ \text{Ab}_{43}\text{An}_{57}\text{ (System II)} \end{cases}$, P: Pyroxene, O: Iron ore.

Fairly good agreement is obtained between the calculated and the observed values for the rocks of Western Dacite group, as expected from the fact that the assumed end members are all taken from this group. Some discrepancies found in specimens 212 and 214 may be attributed to the anomaly in the contents of Al_2O_3 and K_2O.

Circumstances are different in the rocks of the Eastern Group: first, although the agreement in the mean composition of this group is quite remarkable, the calculated content of each end member differs considerably from its modal content (cf. Table 2); secondly, no good agreement for each specimen is obtained. These facts may imply that the relation of the two groups is not a straight one, but a parallel one, even if they have a certain genetic familiality.

In the course of crystallization, feldspar in these acidic rocks may be expected to take a little more potassium and this may cause the discrepancy as observed here. Therefore, another system of approximation was attempted (Table 7, system II). Instead of An-Ab combination, $Ab_{43}An_{57}$-$Or_{30}Ab_{70}$ combination is assumed in this system. (Phenocryst feldspar of Western Dacite lies also upon this line.) Results of calculation are given in Table 8 together with those of system I. General agreement is rather similar to that in the former system, besides against expectations, still poor in Al_2O_3 and K_2O. Thus the definite explanation as to the compositional variation is still difficult, especially in the rocks of Eastern Group.

It is interesting to note that close approximation is achieved for the rocks having no apparent relation to the Hotoke-iwa rocks, namely specimens 242B and 1011. For specimen 242B, however, some discrepancy in Al_2O_3 content is noticeable, as expected also from the normative composition.

Further investigations are needed on these points as well as on the problem of relationships among various rocks of Asama.

6. Conclusion

The rocks of Hotoke-iwa volcanic body can be divided into two groups. There is some variation in chemical composition even among the rocks of each group, and this variation can be, at least partially, explained by the variation of the content of phenocryst minerals in these rocks. The two groups of rocks may not be directly related, i.e., these rocks might have traced a somewhat different course of differentiation from each other.

Acknowledgement

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16. 浅間山仏岩火山体岩石の主化学成分組成

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浅間山仏岩火山体の石英安山岩類（黒曜岩を含む）につき 12 個の試料を採集し，これを迅速法によって分析した．その結果，この火山体の岩石に 2 つのグループが区別されたが，岩石の外見的特徴と化学組成との間には，直接的な関係は認められない．

各試料の間にみられる組成の相違を説明するために，適当に見積もられた組成をもつ 5 個の end member の一次結合で分析値を近似する試みを，最小自乗法によって行なつた．その結果，この相違の少くともある部分は，斑晶鉱物の量の差に由来するとして説明が可能である．