51. *On Some Lavas of Volcano Huzi (Fuji).*

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Introduction.

The world-famous dormant volcano Huzi, situated near the shore of Suruga Bay, occupies an area of about 832 sq. km, with its summit 3776 m above sea level, the highest in Japan. It is a regular and beautiful symmetrical cone with gracefully curving slopes diminishing from 34° near the summit to 17° in the middle, on all sides except the southeast, where a prominent shoulder, Hôei-zan, about 1000 m below the summit, gives it a remarkable profile. This projection is part of the wall of a large explosion-crater that opened at the time of the last great explosion of the volcano in 1707. As may be seen on the steep inner slopes of the Hôei-zan explosion-crater or in the Ôsawa valley that deeply cuts the western slope, it is a typically stratified volcano, formed by the accumulation of many successive lava-flows, intercalated with layers of fragmentary materials, bombs, scoriae, lapilli, ashes, etc. The parasitic knobs of the volcano, of which there are more than forty, are either lava or cinder cones.

As is natural with a mountain of such celebrity as Huzi, there is, besides an extensive popular literature of a descriptive character, quite a number of contributions[1] to the geology of the volcano. An examination of some of the earlier works, however, reveals certain conflicts of opinion in the matter of the structure of the volcano, and of the sequence of its lava-flows. As to its petrography, the only available data are those by T. Wada (1882) and by T. Hirabayashi (1899), who described the Huzi rocks as anorthite-basalt and plagioclase-basalt respectively. It was while making a detailed study of the volcanoes of the Idu district, which, adjoining the southeast of Huzi are com-

1) WADA, *Trans. Scis. Soc., Japan*, **4** (1882), 31~37.
T. SUZUKI, *Expl. Text Geol. Surv. Map* (1:200000) "Huzi", (in Japanese).
T. HIRABAYASHI, *Rep. Earthq. Inv. Comm.*, **24** (1899), (in Japanese).
H. ISHIWARA, "Geogr. and Geol. of Huzi", (1928), (in Japanese).
T. KATO and K. IHARA, *Guide-Book*, Pan-Pacific Sci. Congr., Tôkyô, (1926).
S. KAMBARA, *Jour. Geogr. Soc., Tokyo*, **47** (1935), 109~123, (in Japanese).

prised in the Huzi Volcanic Zone, that the writer became interested in the geology and petrology of Huzi, with the result that within the last few years the writer made several trips to the volcano in accompany with S. Kambara, a civil engineer, who, for the last twenty years has made it a point to utilize his spare time in surveying the sequence of the Huzi lava-flows, devoting special attention to the subject. Since nothing like a complete systematic study, geological as well as petrological, of the volcano has yet been made, the writer offers here as a sort of reconnaissance a short account of the occurrence, together with the microscopical and chemical characters, of six rock specimens from the volcano.

He takes this opportunity of thanking Dr. S. Kambara for his guidance in the field.

Occurrence.

The rocks described in this paper are

1. Lava F_{67-a} (Olivine-bytownite-basalt).
2. Lava F_{67-b} (Two-pyroxene-bearing olivine-bytownite-basalt).
3. Lava F_{67-d} (Augite-bearing olivine-bytownite-basalt).
4. Lava F_{67-e} (Hypersthene-augite-olivine-bytownite-basalt).
5. Aokiga-hara lava (Two-pyroxene-olivine-bytownite-basalt).
6. Hôei-zan scoria (Augite-bearing olivine-bytownite-basalt).

Of these six basalts, numbers 1~4 occur at Makuiwa, about 1580 m above sea level on the S. E. slope and about 2800 m S. E. of Hôei-zan. The exposure here is shown in Fig. 1, where a, b, d, and e correspond to 1~4 respectively.

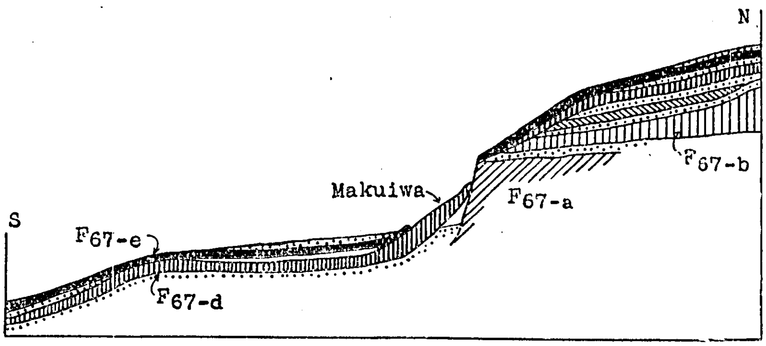

Fig. 1. Diagrammatic section at Makuiwa on the S. E. flank of Huzi. Length of section=300 m approx. Vertical scale much exaggerated.

Lava F_{67-a}, which is the oldest of all the lava-flows exposed at this locality, the base of which however is not exposed, is highly vesicular, ropy in places, with a thickness of more than 10 m. Lavas of this type, which closely resemble Hirabayashi's Misima-Ômiya lava, and which are believed to have poured out at a later period of the extrusion of the latter, are extensively distributed as the lowest exposed lava about the middle height of the southern slope, occupying the valley floors that deeply cut the slope.

Lava F_{67-b}, which is a little later eruption than F_{67-a}, lies on the latter, some pyroclastic beds being sandwitched in between them. Here it occurs as a compact lava-flow, more than 15 m thick, forming an almost perpendicular lava-cliff. Lavas of this type, which are comprised in Hirabayashi's Ôsawa lava, are also widely distributed above the middle height of the southern slope, being exposed as numerous flows alternated by pyroclastic materials, the best exposures of which are met with on the precipitous cliffs of the Ôsawa valley.

Lava F_{67-d}, which occurs as a scoriaceous flow, about 2 m thick, lies on a higher horizon than F_{67-b}. At the locality just mentioned, the lava hangs as a lava-fall over the edge of a precipitous cliff of lava F_{67-a}— a feature likened to that of a hanging curtain. The locality name "Makuiwa" (curtain rock) seems to have originated from that feature. Between the two flows, F_{67-b} and F_{67-d}, is another lava-flow, about 2 m thick, besides pyroclastic materials.

F_{67-e}, which is the youngest exposed lava at Makuiwa, resembles the preceding lava, occurring as a flow, about 2 m thick, and overlying the latter together with some pyroclastic materials.

The Aokiga-hara lava which, in 864 A. D., poured out of the boccas on the N. W. flank, about 2300 m above sea level, and flowed down toward the northwestern foot, is the most conspicuous flow now exposed on the volcano. It covers an area of about 32 sq. km, the greater part of which is thickly forested with conifers. Although the surface of the flow is highly vesicular and broken into blocks that are piled in confused wave-like ridges, its interior is rather compact, retaining many lava-tunnels, -tree-moulds, -caves, etc. Another lava, which probably dates from the same time as the Aokiga-hara lava, is the "Ken-marubi" lava that poured out of the N. W. flank and flowed down northeastward to the vicinity of the town of Yosida.

The Hôei-zan scoria is a lava-fragment that was ejected in 1707, at the time of the great explosive eruption from the S. E. flank of the volcano. The pyroclastic materials, bombs, scoriae, lapilli, ashes, etc., that were ejected from Hôei-zan, a newly opened explosion-crater, spread eastward over more than 50 sq. km. The sample of the Hôei-zan scoria here described was collected on the eastern slope of Hôei-zan.

Megascopic Characters.

Lava F_{67-a}. This rock is dark gray and more or less scoriaceous, with, round or oval, vesicles more than 1 mm dia. Plagioclase phenocrysts, which vary in diameter from 2 mm to 1 cm, dominate; while olivine phenocrysts, which is less than 1 mm dia., are rare.

Lava F_{67-b}. This rock is light-gray and non-vesicular. The phenocrysts, which are usually less than 1 mm dia., are plagioclase, olivine, and pyroxene, of which the plagioclase phenocrysts are fairly abundant, although not conspicuous, being scattered through an aphanitic, pale-gray groundmass. The olivine is only sporadically found; rarely two or three individual minerals forming a grouped phenocryst, about 5 mm in diameter. The pyroxene phenocrysts are far less in quantity than the preceding.

Lavas F_{67-d} and F_{67-e}. Megascopically, these two rocks resemble each other. They are dark gray, vesicular, and porphyritic with phenocrysts of plagioclase (1∼3 mm), olivine (1 mm), and pyroxene (less than 1 mm dia.).

Aokiga-hara lava. This also closely resembles the preceding rocks. It is slightly vesicular, dark gray to almost black, and studded with prominent, white phenocrysts, 1∼2 mm dia., of plagioclase, and also with less conspicuous granules, 0·5∼1 mm dia., of olivine and pyroxene.

Hôei-zan scoria. This rock fragment is angular, about 10 cm dia., black, and vesicular with abundant pores (2 mm dia.) uniformly distributed through the rock; only a few plagioclase phenocrysts, rarely over 0·5 mm across, being visible.

Microscopic Characters.

Microscopically, all the six basalts are porphyritic, with phenocrysts

Table I. Modal Compositions (Vol. %) of the Huzi Basalts.

		I	II	III	IV	V	VI
Phenocrysts	Bytownite	21·04	6·71	20·47	23·10	25·15	7·37
	Hypersthene	—	tr.	—	0·21	tr.	—
	Augite	—	tr.	tr.	0·33	0·07	0·02
	Olivine	1·84	2·60	1·60	1·62	2·84	0·87
Groundmass		77·12	90·69	77·93	74·74	71·94	71·74
Total		100·00	100·00	100·00	100·00	100·00	100·00
Vesicles		1·99	—	8·35	9·86	2·29	35·22

I. Lava F_{67-a}, II. Lava F_{67-b}, III. Lava F_{67-d}, IV. Lava F_{67-e}, V. Aokiga-hara lava, VI. Hôei-zan scoria.

of plagioclase and olivine, irrespective of the presence of pyroxene phenocrysts (Figs. 3～8). The phenocrysts are present in variable quantities in all of them; their volume percentages measured micrometrically being shown in Table I, in which the volume percentages of the vesicles in each rocks are also shown.

Phenocrysts.

It will be seen from Table I that the amount of plagioclase phenocrysts is now more than 20% by volume in all the rocks except F_{67-b} and the Hôei-zan scoria, and that the phenocrysts of the mafic minerals (olivine with or without pyroxene) form only a small percentage in these rocks. In F_{67-b}, the phenocrystic plagioclase is hardly distinguishable quantitatively from that mineral in the groundmass, the mineral varying in size gradually from 0·02 mm × 0·1 mm in the groundmass up to 0·5 mm × 1·7 mm in the phenocrysts, for which reason the amount of the mineral in this lava as shown in Table I indicates only approximately those larger than about 0·5 mm dia. In the Hôei-zan scoria, plagioclase occurs lath-shaped microphenocrysts, less than 0·03 mm × 0·5 mm, although a few larger phenocrysts, 0·5 mm average diameter, are found, so that the amount of the mineral has diminished to 7·37%.

The plagioclase phenocrysts, which are euhedral and lath-shaped, are usually twinned. Zonal structure due to chemical difference is usually absent, though rarely a very faint zoning is observed. According to the refractive indices measured with Tsuboi's dispersion method, the phenocrysts are identified as bytownite as shown in Table II.[2] Although the smaller phenocrysts in F_{67-b} and the Hôei-zan scoria are medium bytownite, the larger phenocrysts in these rocks are identified as anorthite $Ab_5\ An_{95}$. The inclusions commonly found in the plagioclase phenocrysts are glass, either colorless or dark-brown. The phenocrysts in lavas F_{67-b}, F_{67-d}, and F_{67-e} have inclusions of pyroxene and magnetite grains, besides the glass base.

Table II. Composition of the Plagioclase and Optical Data of the Mafic Minerals in the Huzi Basalts.

		I	II	III	IV	V	VI
Plagioclase	phenox.	$Ab_{27}An_{73}$	$Ab_5\ An_{95}$ / $Ab_{16}An_{84}$	$Ab_{25}An_{75}$	$Ab_{28}An_{72}$	$Ab_{29}An_{71}$	$Ab_5\ An_{95}$ / $Ab_{17}An_{83}$
	gr. m.	$Ab_{33}An_{67}$	$Ab_{26}An_{74}$	$Ab_{29}An_{71}$	$Ab_{31}An_{69}$	n.d.	$Ab_{22}An_{78}$

(*to be continued.*)

2) The plagioclase phenocrysts in numerous Huzi lavas, which are not described in this paper, are also bytownite, nearly $Ab_{25}An_{75}$ by chemical composition.

Table II. (*continued.*)

		I	II	III	IV	V	IV
Hypersthene (phenox.)	n_{1D}	——	1·6987	——	1·6983	1·6983	——
	n_{2D}		1·7077		1·7078	1·7076	
Augite	phenox. n_{1D}	——	1·6967	1·6956	n.d.	1·6979	n.d.
	phenox. 2V(+)		n.d.	52°	n.d.	n.d.	n.d.
	gr. m. 2V(+)	52°	{51° 41°	n.d.	n.d.	n.d.	——
Olivine (phenox.)	α_D	n.d.	1·6794	1·6667	n.d.	n.d.	1·6788
	β_D		1·6985	1·6843			1·7002
	2V(−)	84°	85°	n.d.	84°(?)	86°	84°

I. Lava F_{67-a}, II. Laba F_{67-b}, III. Lava F_{67-d}, IV. Lava F_{67-e}, V. Aokiga-hara lava, VI. Hôei-zan scoria.

Hypersthene phenocrysts, euhedral and 0·3～1 mm long, are found in F_{67-b}, F_{67-e}, and Aokiga-hara lavas in amounts as shown in Table I. Although the mineral could not be detected in two thin sections of F_{67-b}, a megacryst picked out of the lava was identified by its opitical characters as hypersthene. The hypersthene in F_{67-e} is moderately pleochroic (Z—pale green, X or Y—pale brown); its optical plane being parallel to the c-axis. It often has a border of monoclinic pyroxene. The enclosures in it are anhedral olivine grains and euhedral plagioclase prismoids. The hypersthene in the Aokiga-hara lava, which is less pleochroic than the preceding, has enclosures of euhedral plagioclase. In the same lava anhedral hypersthene is rarely enclosed in olivine phenocrysts. The refractive indices measured on cleavage (110) flakes are given in Table II, according to which the approximate chemical composition of the mineral as estimated by the Tomita diagram[3] is $(MgSiO_3)_{67}(FeSiO_3)_{33}$, showing that the difference in the chemical composition of the mineral in the three lavas is small.

Although augite phenocrysts are found in small quantities in all the rocks except lava F_{67-a}, in F_{67-b} and F_{67-d} the mineral occurs as microphenocrysts exhibiting undulatory extinction. In lava F_{67-e}, augite forms euhedral pale-brown phenocrysts, 0·2～1 mm across, as also in the Aokiga-hara lava. They have enclosures of anhedral olivine. In the Hôei-zan scoria a few pale-brown augite, about 0·3 mm dia., are detected. The refractive indices on the cleavage (110) flakes of the mineral in F_{67-b}, F_{67-d}, and in the Aokiga-hara lavas are given in

3) T. TOMITA, *Jour. Geol. Soc., Tokyo*, **31** (1924), 364, (in Japanese).

Table II. The optic axial angle measured on the crystals in a thin section of F_{67-d} is 52°.

The olivine phenocrysts, which are present in all the six basalts, though in rather small amounts, are euhedral to anhedral, 0·1∼1 mm dia., and in thin sections pale yellowish-green or nearly colorless. In the F_{67-b} and the Aokiga-hara lavas the mineral is surrounded by iron-oxide and minute grains of a monoclinic pyroxene, while in lava F_{67-d} it is surrounded only by iron-oxide; and in the remaining rocks by none of these substances. Besides the minute crystals (plagioclase, pyroxene, and magnetite) which are supposed to have crystallized out of the glass enclosures, brown glass is the commonest enclosure in this mineral. The refractive indices and the optic axial angles of the mineral as far as estimated are shown in Table II, according to which the composition of the mineral in the F_{67-b}, F_{67-d}, and Hôei-zan scoria are $Fo_{78}Fa_{22}$, $Fo_{84}Fa_{16}$, and $Fo_{78}Fa_{22}$ respectively.

Groundmass.

The six basalts differ in the crystallinity of the groundmass. The rocks show moreover different crystallinities in their different parts, although generally the groundmass of all the basalts, except F_{67-b}, is hyalocrystalline to dohyaline, consisting of minute plagioclase prismoids, pyroxene and magnetite grains, together with a dark-brown glass base, the proportions of which cannot be measured accurately with the micrometer. Table I shows the percentage of the groundmass calculated by difference. The plagioclase, which is generally less than 0·2 mm long, is either calcic labradorite or sodic bytownite. The pyroxene is usually granular, under 0·1 mm dia. and pale-brown. Although its optical properties could not be accurately determined, it is always of monoclinic variety. The optic axial angle measured on several crystals in a thin section of F_{67-a} was approximately 52°. The groundmass of F_{67-b} is docrystalline to percrystalline, consisting of sodic bytownite (0·05∼0·3 mm long), pale-brown monoclinic pyroxene (under 0·1 mm dia.), magnetite granules (0·05 mm dia.), and a little glass. The pyroxene in this groundmass exhibits undulatory extinction. The optic axial angle measured on some crystals of the mineral was 51°, but on others in the same section, 41°. Notwithstanding the high crystallinity of this groundmass, no silica minerals could be detected.

Chemical Characters.

Bulk Composition.

Chemical analysis of the Huzi rock was first made by T. Wada and Korschelt. Another analysis, cited by Wada[4], was made by Lue-

4) T. WADA, *loc. cit.*

decke. Although the writer has not seen the original papers, in which these analyses were published, they are not very satisfactory, seeing that Wada had some misgivings in regard to them. A rock specimen collected by Schütt from the wall of the summit crater of the volcano was analyzed by M. Hida under Korschelt's direction. The result of the analysis, Table III, A, which was published by Wada in his paper above referred to, and which showed the basic character of the rock, has since been accepted by many authors, together with those of other Japanese basic volcanic rocks. Recently, S. Kozu[5] published analyses of three rocks (Table III, B, C, D) of the volcano. Of these three rocks analyzed, the basal lava seems to represent one of the older lavas, the

Table III. Old Chemical Analyses of the Huzi Basalts.

	A	B	C	D
SiO_2	49·77	49· 2	49·95	50·57
Al_2O_3	20·57	19·73	18·65	18·67
Fe_2O_3	6·06	4·37	3·70	6·08
FeO	5·11	6·68	8·34	6·15
MgO	5·00	4·07	5·71	5·10
CaO	10·37	10·66	9·82	10·09
Na_2O	1·08	1·38	1·40	1·46
K_2O	0·84	0·78	0·67	0·79
H_2O+	0·73	0·89	0·67	0·70
H_2O-		0·43	0·18	0·20
TiO_2	——	0·21	0·20	0·24
P_2O_5	0·16	0·19	0·22	0·15
MnO	0·20	0·16	0·18	0·14
Total	99·89	99·47	99·69	100·34

A. Summit lava, analyst M. Hida.
B. Basal lava, locality and analyst not stated.
C. Taka-marubi, analyst not stated.
D. Aokiga-hara lava, analyst not stated.

term "basal" being used in the same sense as that proposed by H. Ishiwara[6] to cover broadly the older lavas (Hirabayashi's Misima-Ômiya lava, Enkyô lava, etc.) of the volcano. Unfortunately however the locality of the analyzed basal lava is not mentioned by Kozu. Taka-marubi is a lava forming a tongue-shaped flow on the N. E. flank of the volcano. The Aokiga-hara lava is the same as that described in this paper.

5) S. KOZU, *Bull. Vol. Soc., Japan*, **1** (1933), 13, (in Japanese).
6) H. ISHIWARA, *loc. cit.*

The six basalts now under consideration were chemically analyzed by S. Tanaka of this Institute, with the results shown in Table IV. The table shows that notwithstanding textural and mineralogical variations, no conspicuous difference is found in the bulk compositions of these

Table IV. New Chemical Analyses of the Huzi Basalts, analyst S. Tanaka.

	I	II	III	IV	V	VI	VII
SiO_2	50·28	50·64	50·66	51·05	51·30	51·09	50·84
Al_2O_3	18·30	18·58	18·25	18·35	18·75	17·62	18·31
Fe_2O_3	4·50	3·04	4·78	2·76	1·83	2·64	3·26
FeO	6·89	7·29	5·72	7·72	8·34	8·42	7·40
MgO	3·80	5·58	4·94	4·63	4·80	5·09	4·81
CaO	9·76	10·00	9·98	9·90	9·76	9·68	9·85
Na_2O	2·87	2·64	2·78	2·81	2·55	2·80	2·74
K_2O	0·94	0·61	0·77	0·81	0·71	0·76	0·77
H_2O+	0·20	0·20	0·38	0·40	0·22	0·28	0·28
H_2O-	0·08	0·06	0·13	0·11	0·06	0·06	0·08
TiO_2	1·78	1·15	1·38	1·41	1·43	1·38	1·42
P_2O_5	0·34	0·16	0·25	0·24	0·29	0·26	0·26
MnO	0·20	0·17	0·17	0·18	0·28	0·21	0·20
Total	99·94	100·12	100·19	100·37	100·31	100·29	100·22
Norms							
Q	3·96	1·98	4·14	2·34	2·82	2·04	2·76
Or	5·57	3·34	4·45	5·01	4·45	4·45	4·45
Ab	24·14	22·55	23·59	23·59	21·50	23·59	23·07
An	34·49	36·99	35·05	35·05	37·55	33·38	35·60
Di $CaSiO_3$	5·11	4·88	5·34	5·23	3·83	5·46	5·26
Di $MgSiO_3$	3·01	2·81	3·61	2·81	1·91	2·81	2·91
Di $FeSiO_3$	1·85	1·85	1·32	2·24	1·85	2·51	2·11
Hy $MgSiO_3$	6·42	11·04	8·73	8·73	10·04	9·84	9·03
Hy $FeSiO_3$	4·62	7·39	3·30	7·65	10·16	8·84	6·86
Mt	6·48	4·40	6·95	3·94	2·55	3·94	4·63
Il	3·34	2·12	2·58	2·73	2·73	2·58	2·73
Ap	0·62	0·31	0·62	0·62	0·62	0·62	0·62

I. Lava F_{67-a}, II. Lava F_{67-b}, III. Lava F_{67-d}, IV. Lava F_{67-e}, V. Aokiga-hara lava, VI. Hôei-zan scoria, VII. Average of the six basalts.

rocks. The silica percentage is fairly constant, varying from 50·28% in F_{67-a} to 51·30% in the Aokiga-hara lava, and so are also the percentages of the other oxides. In iron-oxides, some variations occur, but the total iron-oxide ($FeO+Fe_2O_3$) is almost the same in all cases.

According to the C. I. P. W. quantitative system, they fall under *hessose* (II, 5, 4, 4∼5), with the norms as shown in the same table, which means that the Q/F in them is always smaller than 1/7.

A comparison of Table III and IV shows fairly wide differences in the amounts of some oxids, the amount of Na_2O in Table III being always less than 1·5%, and that in Table IV more than 2·5%; in other words, the normative plagioclase calculated from the old analyses is always less sodic (medium bytownite $Ab_{15}An_{85}$∼$Ab_{23}An_{77}$) than that from the new analyses (medium labradorite, see Table V). Thus, although (D) in Table III is the analysis of the same rock as Aokiga-hara lava represented by (V) in Table IV, there is some discrepancy between them; the normative plagioclase of the former ($Ab_{23}An_{77}$) being more calcic than the modal plagioclase phenocrysts ($Ab_{29}An_{71}$) contained in the Aokiga-hara lava, while the normative plagioclase of the latter ($Ab_{36}An_{64}$) is more sodic than this modal one. Moreover, analysis (D), instead of falling under *hessose*, to which the new analysis of the Aokiga-hara lava belongs, does so under *bandose* (II, 4, 4, 4), which means Q/F>1/7. If the two analyses of the Aokiga-hara lava are both correct, these discrepancies are somewhat puzzling, unless we assume that they represent several different facies in the same lava-flow. Since the microscopic characters of the rock specimen represented by analysis (D) have not been published, it is impossible to decide whether or not the specimen differs in microscopic characters from the Aokiga-hara lava described in this paper. In the following discussion, therefore, analysis (V) in Table IV, which seems preferable to the writer, is adopted as correctly representing the chemical composition of the Aokiga-hara lava. Analysis (A) also falls under *bandose*, while (B) and (C) does so under *hessose*.

Table V.

		I	II	III	IV	V	VI
Norm plagioclase		$Ab_{41}An_{59}$	$Ab_{38}An_{62}$	$Ab_{40}An_{60}$	$Ab_{40}An_{60}$	$Ab_{36}An_{64}$	$Ab_{41}An_{59}$
Norm pyroxene	$CaSiO_3$	24	17	22	19	14	18
	$MgSiO_3$	50	57	61	49	49	49
	$FeSiO_3$	26	26	17	32	37	33
$\frac{FeO(+Fe_2O_3)\times 100}{FeO(+Fe_2O_3)+MgO}$		74	64	67	69	68	68

Table V, besides giving the compositions of the normative plagioclase (wt. %) and the normative pyroxene (mol. %), gives also the proportion of the total iron-oxides against magnesia in the six basalts, as calculated from the analyses of Table IV. Although no definite relation can be recognized between the normative plagioclase and the ratio FeO : MgO in the rocks, it is accepted that the amount of $FeSiO_3$ in the normative pyroxene is larger in the younger rocks (IV, V, VI) than in the remaining ones.

Composition of Groundmass.

The approximate chemical compositions of the groundmass of porphyritic rocks will be obtained by subtracting the total amounts of the phenocrystic minerals, whose compositions may be estimated from their optical constants, from the bulk compositions of the rocks. As is clear from Table I, the phenocrysts found in greatest abundance in the Huzi rocks are plagioclase. Although there is usually only a very small amount of mafic phenocrysts in these rocks, olivine predominates over pyroxene, the amounts of which are quite negligible. Table VI gives the results of the subtraction of the plagioclase and olivine phenocrysts from the four rocks–F_{67-a}, F_{67-d}, F_{67-e}, and Aokigahara lavas, all of them containing these phenocrysts. In the table, (I) may depart but little from the actual groundmass composition of the corresponding rock, while the remaining ones represent only approximately the groundmass compositions of the respective rocks, seeing that they contain small amounts of pyroxene phenocrysts that were neglected in the calculation of the groundmass composition. It will be seen at

Table VI. Calculated Groundmass Compositions of the Huzi Basalts.

	I	III	IV	V	X	XI
SiO_2	50·63	51·25	51·57	52·37	51·46	49·70
Al_2O_3	14·87	14·95	14·48	14·51	14·70	14·24
Fe_2O_3	5·81	6·11	3·65	2·51	4·52	3·66
FeO	8·52	6·99	9·88	10·88	9·07	9·96
MgO	4·13	5·41	5·44	5·40	5·10	6·82
CaO	8·54	8·80	8·57	8·11	8·51	9·55
Na_2O	2·85	2·82	2·73	2·52	2·73	2·64
K_2O	1·21	0·98	1·07	0·98	1·06	0·70
H_2O+	0·25	0·49	0·53	0·30	0·39	——
H_2O-	0·10	0·16	0·14	0·08	0·12	——
TiO_2	0·29	1·76	1·86	1·97	1·97	2·23
P_2O_5	0·44	0·31	0·32	0·40	0·34	0·33
MnO	0·25	0·21	0·23	0·38	0·27	0·17

(*to be continued.*)

Table VI. (*continued.*)

	I	III	IV	V	X	XI
Norms						
Q	6·07	6·37	3·90	5·41	5·35	0·90
Or	7·24	5·57	6·12	5·57	6·12	3·90
Ab	24·12	23·59	23·07	21·50	23·07	22·55
An	24·20	25·59	24·20	25·31	24·76	25·03
Di $CaSiO_3$	6·27	6·85	6·97	5·19	6·62	8·59
Di $MgSiO_3$	3·51	4·52	3·51	2·41	3·61	4·92
Di $FeSiO_3$	2·51	1·85	3·30	2·77	2·77	3·30
Hy $MgSiO_3$	6·73	8·93	10·04	11·04	9·03	12·05
Hy $FeSiO_3$	5·14	3·43	9·23	12·40	7·39	8·57
Mt	8·33	8·80	5·33	3·70	6·48	5·32
Il	4·40	3·34	3·49	3·79	3·79	4·25
Ap	0·93	0·62	0·62	0·93	0·62	0·62

I. Lava F_{67-a}, III. Lava F_{67-d}, IV. Lava F_{67-e}, V. Aokiga-hara lava, X. Average of the four, XI. Average of 43 plateau basalts, calculated as water free.[7)]

any rate that the approximate groundmass composition of Huzi rocks resembles the composition of some plateau basalts (Table VI, XI). Generally speaking, however, the former is more silicic than the plateau basalts from other parts of the world. Compared with the Mull rocks, for example, the groundmass composition of Huzi rocks resembles more the "Non-Porphyritic Central Magma type" than it does the "Plateau Magma type".[8)] The rocks of Huzi may be considered to have been derived from a mother liquid more basic than the liquid such as their groundmass would seem to suggest, the relation between these two magmatic liquids being much like that between the two magma types[9)] of Mull just mentioned.

Table VII.

	I	III	IV	V	X	XI
Norm plagioclase	$Ab_{50}An_{50}$	$Ab_{48}An_{52}$	$Ab_{49}An_{51}$	$Ab_{43}An_{54}$	$Ab_{48}An_{52}$	$Ab_{48}An_{52}$
Norm pyroxene $CaSiO_3$	25	25	21	15	22	22
Norm pyroxene $MgSiO_3$	48	58	47	46	48	51
Norm pyroxene $FeSiO_3$	27	17	32	39	30	27
$\frac{FeO(+Fe_2O_3)\times 100}{FeO(+Fe_2O_3)+MgO}$	77	69	71	71	72	66

7) R. A. DALY, "Igneous Rocks and the Depths of the Earth", (1933).
8) H. H. THOMAS and E. B. BAILEY, *Mem. Geol. Sur., Scotland*, (1924).
9) N. L. BOWEN, "The Evolution of the Igneous Rocks", Princeton, (1929).

Table VII, besides giving the compositions of the normative plagioclase (wt. %) and the normative pyroxene (mol. %), gives also the proportion of total iron-oxides against magnesia, as calculated from Table VI. It shows that the average groundmass (X) of the rocks of Huzi agrees approximately with the average plateau basalt (XI) in the compositions of both normative plagioclase and pyroxene, except that the former is more ferriferrous than the latter (see Fig. 2).

Comparison of Huzi Basalts with Allied Rocks of the Adjoining Idu District.

In the Idu region, which comprises, in addition to the peninsula of that name, the outlying group of small islands called the Idu Sititô (Seven Idu Islands), are several basaltic volcanoes; Ô-sima, Miyaké-zima, etc., in the Idu Sititô, and the Taga volcano and several parasitic cones of the composite Amagi volcano in the Idu peninsula, all built up of basaltic rocks that erupted either in the Diluvial age or in the Recent. Besides these, there are in the peninsula a number of local lava-flows and intrusive sheets of basaltic nature, ranging in age from Lower Miocene to Pliocene. Upon comparing them with the basalts of Huzi, these basaltic rocks have some characteristic features, microscopical as well as chemical. Without however attempting any detailed discussion of the subject, the writer will now compare the rocks of Huzi with those of the now active Ô-sima volcano as well as of the dormant Miyaké-zima volcano.

S. Tsuboi[10] has offered the view that the basaltic rocks of Ô-sima and Miyaké-zima are genetically related to the rocks of Huzi—a view essentially based on results obtained by means of the optical analysis proposed by him.[11] From the results thus obtained, it is concluded that the porphyritic plagioclase and mafic minerals of the former (Table II) are generally of later stage than these minerals in the latter (Table VIII).

Table VIII.

	I	II
Plagioclase	$Ab_{15}An_{85}$	$Ab_{13}An_{87}$
Hypersthene	n. d.	$n_{1D}=1{\cdot}6927$ $n_{2D}=1{\cdot}7000$
Augite	$n_{1D}=1{\cdot}6865$	$n_{1D}<1{\cdot}6927$

I. Basaltic bandaite, somma lava of Ô-sima.
II. Miharaite, 1914 lava of the central cone, Mihara-yama, of Ô-sima.

10) S. Tsuboi, *Bull. Earthq. Res. Inst.*, **4** (1928), 131~138.
11) S. Tsuboi, *ibid.*

A comparison of the rocks of Huzi with the rocks of Ô-sima and Miyaké-zima may be made from the norm contents of these rocks. The normative plagioclase of the former is medium labradorite (Table V), and so is the latter, with the exception of the miharaite, whose normative plagioclase is as calcic as bytownite $Ab_{21}An_{79}$; the normative pyroxene of the former being poorer in $FeSiO_3$ molecule than that of the latter (Fig. 2). The Huzi rocks moreover are distinctly lower in

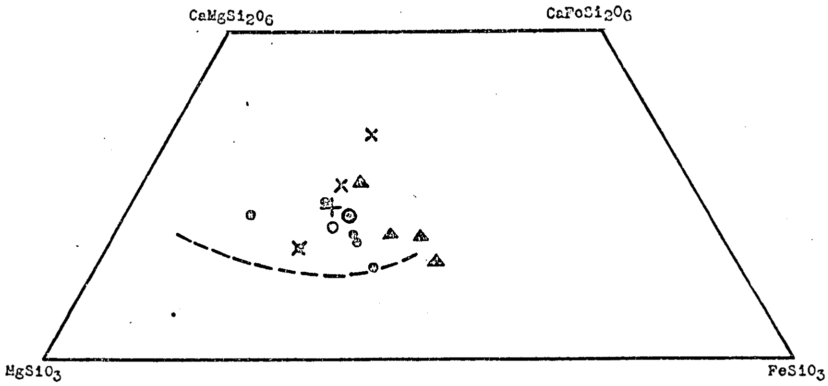

Fig. 2. Compositions of normative pyroxenes in the Huzi basalts and some allied rocks to which reference is made in the text.

⊛ Huzi basalts, ○ Average of the six Huzi basalts, ◉ Average of the groundmass of 4 Huzi basalts, ▲ basaltic rocks of Ô-sima and Miyaké-zima, × "Plateau Magma type" and "Non-Porphyritic Central Magma type" of Mull, + Average of 43 plateau basalts in the world.[12]

Broken line represents the two-pyroxene boundary[13] as inferred from pyroxene-andesites and allied rocks in the Idu district.[14]

the $FeO(+Fe_2O_3)/MgO$ ratio compared with the rocks of Ô-sima and Miyaké-zima. Another important result from a comparison of the norm contents is that the former is as poor in normative quartz as $Q/F<1/7$, although the latter yields normative quartz to such an extent as $Q/F>1/7$. This fact is partly shown by the actual feature in that none of the Huzi rocks so far observed carry silica mineral such as usually met with in the groundmass of the Ô-sima rocks.[15]

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12) R. DALY, *loc. cit.*
13) S. TSUBOI, *Jap. Jour. Geol. Geogr.*, **10** (1932), 67~82.
14) H. TSUYA, *Pan-Pacific Sci. Con., Canada*, (1933), 2394.
15) H. KUNO, *Bull. Earthq. Res. Inst.*, **11** (1934), 382~390.

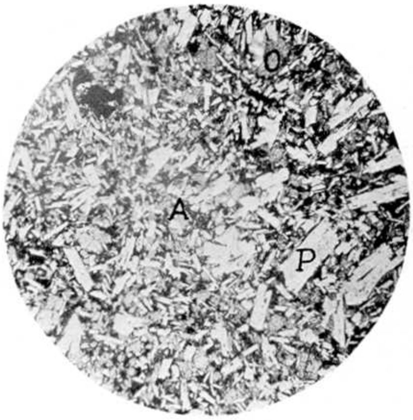

Fig. 3. Groundmass of lava F_{67-a}. A–augite, P–bytownite, O–olivine.

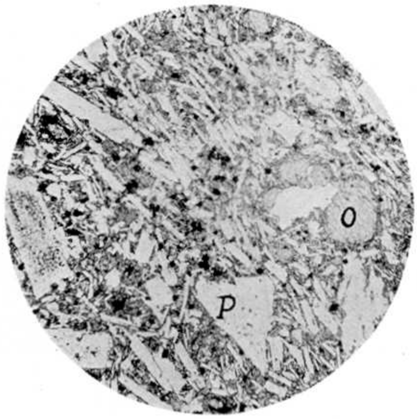

Fig. 4. Lava F_{67-b}. O–olivine, P–bytownite,

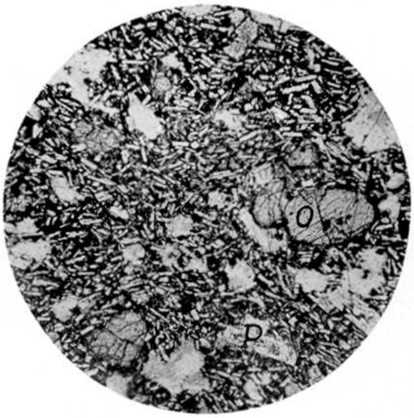

Fig. 5. Lava F_{67-d}. O–olivine, P–bytownite.

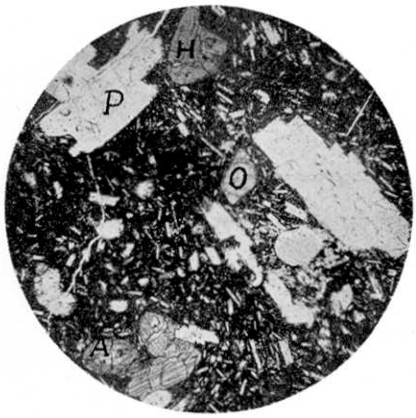

Fig. 6. Lava F_{67-e}. A–augite, H–hypersthene, P–bytownite, O–olivine.

Fig. 7. Aokiga-hara lava. A–augite, H–hypersthene, O–olivine, P–bytownite.

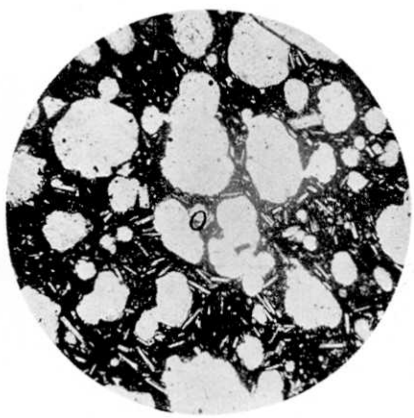

Fig. 8. Hôei-zan scoria. A–augite, O–olivine.

Microphotographs of the Basalts of Huzi (Fuji).
[Magnification in all cases ×15]

（震研彙報 第十三號 圖版 津屋）

51. 富士火山の數種の熔岩に就いて

地震研究所 津屋弘逵

富士火山を構成する熔岩は極めて多數であるが，本文に記載したものは其中次の6種である．

1. 橄欖石・亞灰長石玄武岩 (F_{67}–a)
2. 含複輝石―橄欖石・亞灰長石玄武岩 (F_{67}–b)
3. 含普通輝石―橄欖石・亞灰長石玄武岩 (F_{67}–d)
4. 紫蘇輝石・普通輝石・橄欖石・亞灰長石玄武岩 (F_{67}–e)
5. 複輝石・橄欖石・亞灰長石玄武岩（青木原熔岩）
6. 含普通輝石―橄欖石・亞灰長石玄武岩（寶永山岩滓）

以上の中，1乃至4は富士火山の南東腹海拔 1680 m. 附近の幕岩と稱する處に相重なつて露出してゐる．同處で最も古い熔岩 (F_{67}–a) は平林氏の三島・大宮熔岩（震災豫防調査會報告24號，明治 32 年）の1種に似て直徑 1 cm 內外の亞灰長石斑晶を有するものである．之に次ぐ熔岩 (F_{67}–b) は平林氏の大澤熔岩の1種に似て，斑狀構造の著しくない緻密な灰色玄武岩である．之等は厚さ 10 m 以上の熔岩流をなして露出してゐるが，之等に次ぐ二つの熔岩 (F_{67}–d，F_{67}–e) は黑色岩滓質で厚さ 2〜3 m の熔岩流をなし，他の同種の二三の熔岩流と相重なり，富士火山の比較的新期の噴出物である．青木原熔岩は貞觀6年に同火山の北西腹から噴出した熔岩であり，寶永山岩滓は寶永4年寶永爆裂口から拋出された岩滓質熔岩片である．本文では之等の熔岩に就いて，先づ一般的の顯微鏡的性質を述べ，次に化學分析の結果得られた各熔岩の總化學成分及び此總化學成分と斑晶の化學成分とから推定し得た石基の化學成分に就いて考察し，最後に富士火山熔岩の特性を大島・三宅島等の熔岩の夫と比較論述した．