21. *A Geomagnetic Study of the Minor Activities of Volcano Mihara, Oosima Island, August 1940.*

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1. Introduction.

Thirty-eight days after the beginning of the severe eruption of Miyake-sima, another Volcano, Mihara, in Oosima Island, about 80 km north of Miyake-sima and about 100 km south of Tôkyô, began to show activity. The geophysical aspect of this volcano has been the subject of frequent reports by R. Takahasi and the writer[1], while its geology and petrology have received the attentions of S. Tsuboi[2]. Although this volcano has been rather quiet since the end of the great eruption of 1911∼1914, it has been growing active again since 1938, when, on August 11, there was a minor eruption, the bottom of the pit having turned into an incandescent lava pool, ejecting quantities of porous scoria that fell around the mouth of the pit. After this activity, comparative quiet reigned until eruptions started again in September, the following year. In this activity of 1939, the first eruption occurred on Sept. 2 and continued until the next day, the incandescent lava filling the crater bottom in a pool and throwing up quantities of bomb and scoria, although they did not reach the mouth of the pit; while the second eruption began on Sept. 16 and kept on all that day, the magnitude of the activity being nearly the same as that of the first.

During all these activities, owing to the accumulation of solidified lava masses on the floor of the pit, the depth of the pit became shallower. As measured from the edge of its mouth, the depth of the pit was 289·6 m in Nov. 1936, 298·7 m in Aug. 1937, 255 m in Aug. 1938, 250 m in Oct. 1938, 220 m on Sept. 3, 1939, and 218 m on Sept. 16, 1939, while according to H. Tsuya[3], it was about 400 m in 1933. This ten-

1) R. TAKAHASI and T. NAGATA, *Bull. Earthq. Res. Inst.*, **15** (1937), 441; 1047; **16** (1938), 87.

2) S. TSUBOI, *Journ. Col. Sci. Tokyo Imp. Univ.*, **53** (1920), 1.

3) H. TSUYA, "Volcano" (*Bôsai-Kagaku*) 1935, Tokyo.

dency to shallowing may be seen from a general view of the pit bottom as photographed from a position on the north-east edge of its mouth (Figs. 7, 8, 9). Thus, the bottom-floor of Mihara crater rose after August 1937, although intermittently. According to T. Minakami[4], there is a close relation between the activity of a volcano and the depth of its crater, in Mt. Asama; for example, the crater floor rises before a severe activity and falls after the eruption ends, for which reason, we may expect that Volcano Mihara has recently been getting active.

The geophysical phenomena leading to volcanicity, namely, volcanic earthquakes, volcanic microseisms, earth tilting, earth current, temperature in the fumaroles, volume of emitted gas, numbers and magnitude of rumblings, etc., have been continuously under observation for changes in them that may be related to the present activity. The results of studies of the present activity made from these standpoints will be reported by R. Takahasi in detail. To enable comparison with that in the case of the severe eruption of Miyake-sima volcano[5], we shall give here only an outline of the present activity and the results of our studies from the geomagnetic standpoint.

2. The eruption of August 19, 1940.

Volcano Mihara became active on the morning of Aug. 18. A large fissure opened in the solidified lava sheet that had formed the crater bottom, incandescent bombs being violently ejected from it to heights of more than 100 m from the bottom, along with rumblings and emission of gases, which lasted the whole of the 18th. From about 2h of Aug. 19, volcanic activities increased in violence. Numbers of incandescent bombs and lapilli were ejected accompanied with detonations and

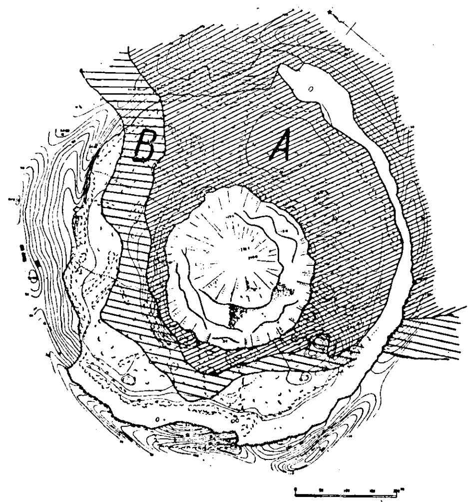


Fig. 1. Distribution of new ejecta (bombs and lapilli) from Volcano Mihara around its pit, August 19, 1940.
A. Covered with new ejecta. (See Fig. 11).
B. Bombs distributed intermittenly. (See Fig. 10).

4) T. MINAKAMI, *Bull. Earthq. Res. Inst.*, 15 (1937), 492.

5) H. TSUYA, T. HAGIWARA, T. MINAKAMI, T. NAGATA S. OMOTE and R. TAKAHASI, *Bull. Earthq. Res. Inst.* 19 (1941), 260.

rumblings, some of the lapilli reaching heights of more than 500 m from the summit of the central cone. The eruptions occurred continuously, until about 6 h of the same day. In the final stage of activity, after a lull from 6h to 6h 35m, intermittent eruptions occurred at 6h 35m,–45 m,–55 m, and 56 m, and 7 h 04 m, two occurring at 7 h 22 m, three final eruptions at 7 h 40 m, when activities ceased.

Almost the entire bottom of the old crater was covered with newly ejected bombs and lapilli, the eastern side of the old crater especially being covered thickly with them, more than 2 m at the thickest part. The distribution of the ejecta is roughly shown in Fig. 1, from which it will be seen that the eastern side of the central cone was also covered with scoria more than 20 cm thick, these ejecta reaching distances as much as 2 km and more east of the crater. Owing to the present activity, the depth of the pit decreased to as little as 180 m from its mouth.

3. Geomagnetic variation following the eruption.

From August 20, the change in geomagnetic dip was observed by means of the dip-variometer at Gozinkatyaya, the north-western summit of the somma of this volcano. The constants and characteristics of this instrument were exactly the same as in the case of the Miyake-sima expedition. The probable error in the present observation was less than 0·2′.

Unfortunately, a typhoon which visited this island a week after observations were begun, disturbed the instrument, with the result that observations had to be suspended until September 3. The daily mean values of observed results are given in Table I and Fig. 2, in which the daily mean values of the dip at the magnetic observatory of the Mitsui Geophysical Institute, at Suzaki, Izu peninsula, are also given. By assuming that the dip-variation at Suzaki shows the general variation in geomagnetic dip in the neighbourhood of Oosima and Izu, the difference $\delta I = \Delta I_{\text{Mihara}} - \Delta I_{\text{Suzaki}}$ gives the amount of local anomalous change at our magnetic station. The values of δI are also shown in Table I and Fig. 2.

It will be seen from these results that the geomagnetic dip at our station gradually decreased about 6 minutes during the four days following the eruption of this Volcano, while that at Suzaki varied only 1·5 minutes from its largest value during the same period. The amount of change, however, is only one fifth of that observed at Miyake-sima after its great eruption. Although a change of 6 minutes in geomagnetic dip is not small compared with that which occurrs as the result of changes in atmospheric conditions, itcan not be said that the observed anomalous changes were all due to the volcanic activity, because

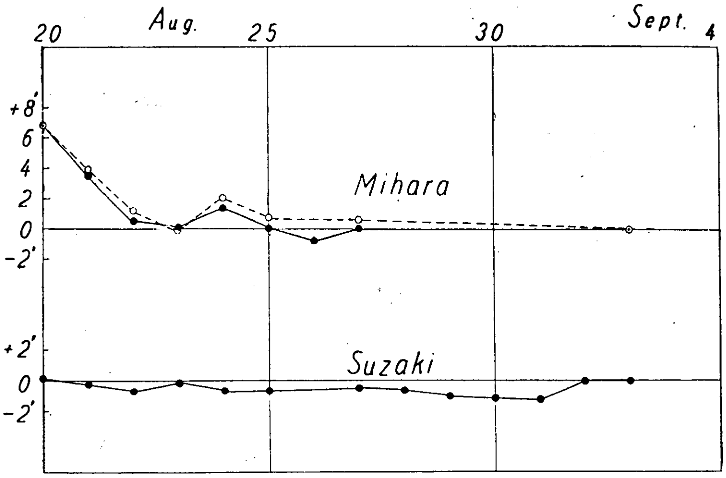


Fig. 2. Daily mean values of dip at Gozinkatyaya and Suzaki. Dotted line gives δI.

Table I. Daily Mean Values of Geomagnetic Dip at Mihara and Suzaki.

Date	ΔI_{Mihara}	ΔI_{Suzaki}	δI	Date	ΔI_{Mihara}	ΔI_{Suzaki}	δI
	min	min	min		min	min	min
Aug. 20	+6·7	+0·1	+6·6	Aug. 27	+0·2	−0·6	+0·8
21	+3·5	−0·3	+3·8	28	—	−0·7	—
22	+0·5	−0·7	+1·2	29	—	−1·1	—
23	+0·2	−0·1	+0·3	30	—	−1·2	—
24	+1·4	−0·7	+2·1	31	—	−1·3	—
25	+0·1	−0·7	+0·8	Sept. 1	—	−0·1	—
26	+0·7	—	—	2	0·0	0·0	0·0

there is always a difference of two or three minutes in dip in the magnetograph records obtained at two different stations, where no disturbance in the earth's crust, i. e. earthquake or volcanic activity, could be observed. Moreover, we should take into consideration that our magnetic station was situated on the summit of the somma, about 600 m above sea level, in a solitary volcanic island, while the other stations were in the open where the space gradient of geomagnetism as well as that of atmospheric electricity seem to be small. Hence, we shall not be far out in concluding that the geomagnetic field near volcano Mihara was not disturbed so much by the present volcanic activity as in the case of Miyake-sima's great eruption, and that if there were any local geomagnetic change, it was smaller than 6 minutes in dip at Gozinkatyaya.

4. Magnetic properties of the new ejecta.

Magnetic susceptibility, the intensity and direction of the natural remanent magnetization, and the characteristic quantities of the thermo-remanent magnetization of the newly ejected bombs from Volcano Mihara in the present activity were measured experimentally.

(i) Chemical composition.

A piece from a large bomb was chemically analyzed in Tsuya's laboratory at our Institute. The chemical and normative compositions are given in Table II, where those of the Meizi-Taisyô lava ejected at the time of the great eruption of this volcano during 1911~1914, analyzed by I. Iwasaki[6], are also given for comparison.

Table II. Chemical Composition of Rocks from Volcano Mihara.

	Bomb ejected Aug. 1940	Lava 1911~1914	Norms	Bomb ejected Aug. 1940	Lava 1911~1914
SiO_2	50·78	52·53	Q	4·63	7·87
Al_2O_3	17·05	15·25	Or	1·67	2·78
Fe_2O_3	3·65	2·69	Ab	13·35	15·73
FeO	8·76	10 57	An	35·38	31·99
MgO	4·55	4·54	Wo	7·67	7·78
CaO	11·08	10·76	En	11·34	11·34
Na_2O	2·20	1·89	Fs	12·13	16·36
K_2O	0·25	0·43	Mt	5·32	3·91
$H_2O(+)$	0·95	n d	Il	1·52	1·37
$H_2O(-)$	0·01		Ap	0·33	0·99
TiO_2	0·77	0·74			
P_2O_5	0·11	0·41			
MnO	0·21	0·24			
Total	100·39	100·16			

(ii) Magnetic susceptibility.

The magnetic susceptibility of the new ejecta was measured by the ballistic method[7] for various intensities of the applied magnetic field, from 0·6 Gauss to 19 Gauss. The specific intensity of susceptibility are given in Table III and Fig. 3. As will be seen from this result, the specific susceptibility of the newly ejected bombs is not fixed, varying

6) I. IWASAKI, *Journ. Chem. Soc. Japan*, **56** (1935), 1511.
7) T. NAGATA, *Bull. Earthq. Res. Inst.*, **18** (1940), 102.

from $0{\cdot}34\times10^{-3}$ to $1{\cdot}27\times10^{-3}$, probably the result of inequality in the structure and chemical composition of the ferromagnetic minerals in the rocks. In such basaltic rocks as the new ejecta from Mihara, the majority of the ferromagnetic minerals usually scattered in the groundmass as microcrystals, whence the magnetic susceptibility of the rock would have various values according to the fine differences in the impurities contained and the size of the microcrystals, even if the total chemical composition as a rock is almost definite. It is worth noting here, however, that the amount of $q \equiv \chi_0/C_{Mt}$ of the rock specimen as chemically analyzed is 2·38—a value slightly differing from its standard value[8].

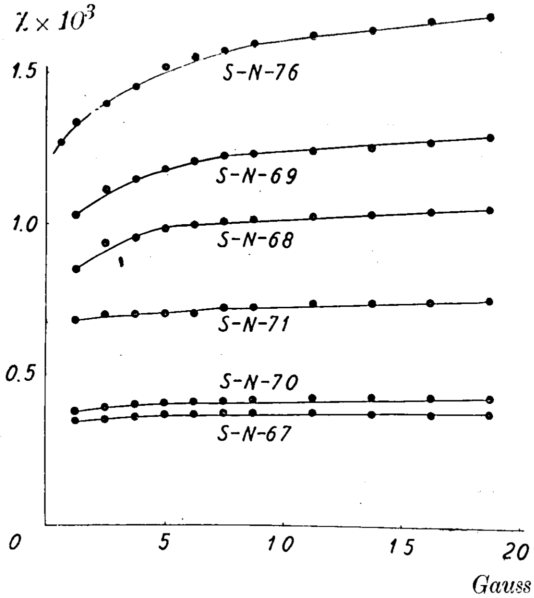


Fig. 3. Specific magnetic susceptibility of the ejecta from Mihara.

(iii) Natural remanent magnetization.

The bombs newly ejected have also intense natural remanent magnetization, exactly as those of the old ejecta from this volcano[9]. Five specimens were broken off by hammer from bombs that exceeded 50 cm in their mean diameters, and from bombs that were believed to be in the same position and direction that they occupied when they fell on the earth's surface.

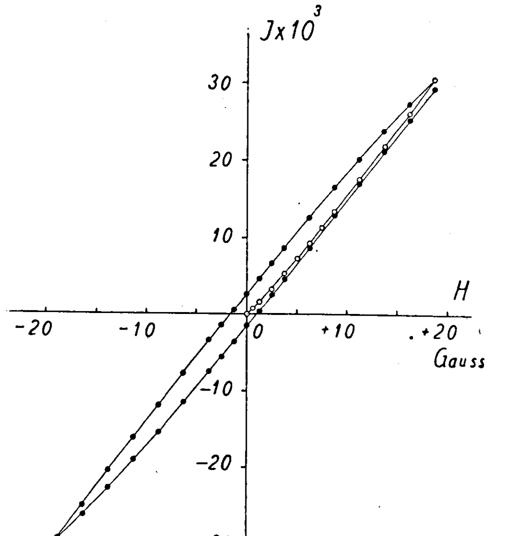


Fig. 4. Hysteresis loop in the magnetization of the new ejecta from Mihara. (Specimen No. 76.)

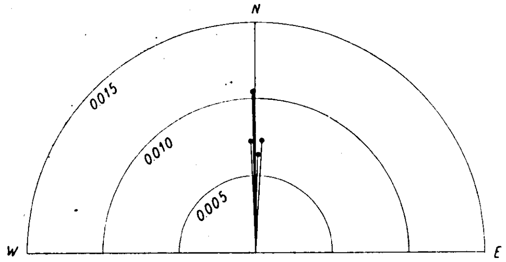
8) T. NAGATA, *Zisin*, **12** (1940), 111.

9) T. NAGATA, *Bull. Earthq. Res. Inst*, **18** (1940), 281.

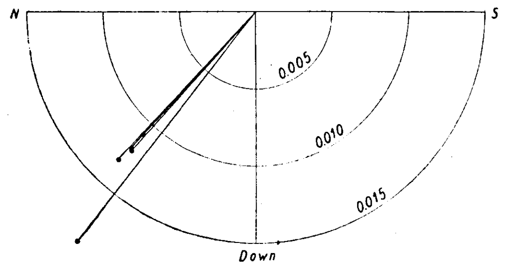
Table III. Magnetic Properties of New Ejecta from Volcano Mihara.

Specimen No.	χ_0	$\Delta\delta$	θ	J_{rn}	Q_n	$J_{tc}\times 0{\cdot}46$	t_0	Remark
67	$0{\cdot}34\times10^{-3}$	1°·5 W	52°·0	$1{\cdot}79\times10^{-2}$	115			
68	0·80 "	3 ·0 W	48 ·0	1·44 "	40	$1{\cdot}54\times10^{-2}$	410°C	
69	0·97 "	2 ·0 E	47 ·5	1·17 "	27			
70	0·37 "	1 ·0 W	47 ·0	1·63 "	99	2·23 "	420	
71	0·68 "	3 ·5 E	47 ·5	1·41 "	46	2·84 "	430	
76	1·27 "	—	—			0·70 "	330	Chemical Analysis

The orientation of these bombs was determined with reference to the vertical and the geomagnetic meridian at an imaginary point 100 cm distant along the normal line from the surface of the bomb at the very spots where they were found. The intensity and direction of the natural remanence of these specimens were measured by magnetometric method. The specific intensity of the natural remanence, its dip-angle, and the deviation of its horizontal component from the geomagnetic meridian, are tabulated in Table III and shown in Fig. 5, where the projection on the horizontal and N–S vertical planes are shown vectorially. The mean value of the specific intensity of these five specimens is $1{\cdot}49\times10^{-2}$, while the mean values of $\Delta\delta$ and θ are $0°{\cdot}0\pm1°{\cdot}2$ and $48°{\cdot}4\pm 0°{\cdot}9$ respectively. Exactly as in the case of bombs newly ejected from Miyake-sima[10], the new bombs from Mihara have also intense natural remanent magnetization, its direction agreeing with that of the geomagnetic field. The fact that the direction of natural remanence agrees



(a) Projection on the horizontal plane.



(b) Projection on the N-S vertical plane.

Fig. 5. Intensity and direction of natural remanent magnetization.

10) *loc. cit.*, Part IV.

with the geomagnetic direction shows that the bombs when they fell on the earth's surface, were at temperatures higher than the transcendental temperatures in the thermo-remanent magnetization.

(iv) Thermo-remanent magnetism.

The partial magnetization during cooling[11] of the specimens were also measured, some of the results being shown in Fig. 6.

The characteristic quantities of thermo-remanent magnetism are also given in Table III, where the t_0 of a specimen is about 300°C, while the others' are nearly 400°C. Since the amounts of $P(t_0)$ and J_{t_c} are fairly large, the rock from Mihara volcano has also the potentiality of undergoing large anomalous geomagnetic changes, as in the case of the Miyake-sima eruption, provided the temperature change in the subterranean rock were fairly large, whence, it may be concluded that since the present volcanic activity was not severe, the subterranean rock was not so disturbed as to result in conspicuous changes in its magnetic intensity.

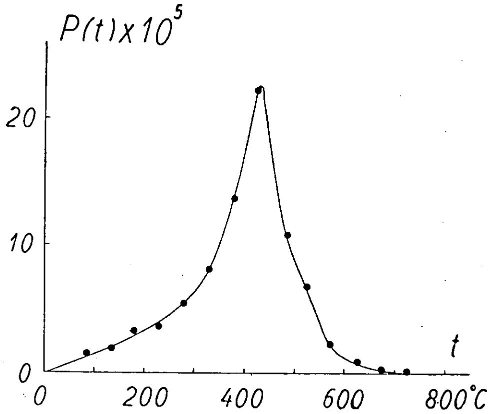


Fig. 6 a. $P(t) \sim t$ relation. (Specimen No. 70.)

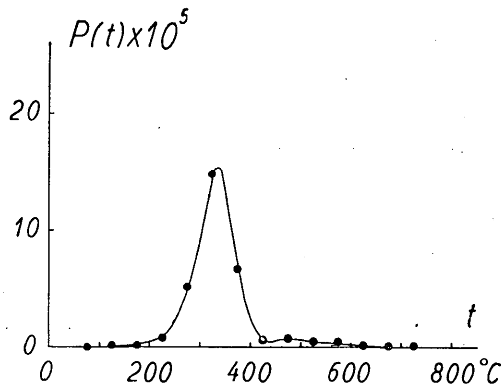


Fig. 6 b. $P(t) \sim t$ relation. (Specimen No. 76.)

5. Summary and Conclusion.

Although the rock specimens newly ejected from Volcano Mihara have fairly large magnetic intensity, nearly the same as those from Miyake-sima, the minor activity of Aug. 19, 1940, was not accompanied by any marked geomagnetic changes, the amount of the changes, after the eruption, if there were any, being smaller than 6 minutes at Gozinkatyaya. This is probably because the present minor activity affected rocks up to only

11) T. NAGATA, *Bull. Earthq. Res. Inst.*, 19 (1941), 49.

a slight area underneath this volcano. Hence, if severe activities again take place in this volcano in future, not an improbability by any means, we may expect that it will be accompanied with great disturbances in the geomagnetic field in its neighbourhood.

In conclusion, the writer wishes to express his sincere thanks to Prof. C. Tsuboi and Prof. H. Tsuya for their continued encouragement in his geomagnetic studies of the earth's crust. His hearty thanks are also due to the Hattori Hôkô Kai, with the aid of whose grant the studies of magnetic properties of the rock were made possible and to Dr. Y. Kosikawa who kindly placed the records of the magnetograph at Suzaki at the writer's disposal.

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21. 昭和 15 年 8 月三原火山小活動に關する地球磁氣學的調査

地震研究所　永　田　武

三宅島噴火開始後 38 日目に伊豆大島の三原火山が活動を開始した．噴火の規模としては明治一大正噴火以後に於いて最大のものであつたが，活動は 8 月 19 日 2 時頃から始まり，7 時には終焉してしまつたので，無數の火山彈，火山礫を拋出したに止り，熔岩は流出しなかつた．三宅島に於けると同様な地球磁氣觀測を行ひ，且つ新噴出物の磁氣的諸性質を調べた．地球磁場はこの活動では著しい擾亂を生ぜず，若し生じたとしても，三原外輪山御神火茶屋附近の伏角に於いて 6′ 以内である．帶磁率，自然殘留磁氣，及び熱殘留磁氣の諸特性を測定した結果，新噴出岩は三宅島新噴出岩と同様に著しい磁性を有してゐる事が分つた．從つて今後若し三原火山に大規模な火山活動が起れば，顯著な地球磁場擾亂の生ずる事が豫想される譯である．

この調査費の一部は服部報公會の援助による．記して同會に對し感謝の意を表す．

Fig. 7. Crater bottom of Volcano Mihara. (Aug. 11, 1938.)
(The incandescent lava pool is seen through the emitted gases.)

Fig. 8. Crater bottom of Volcano Mihara.
(Sept. 3, 1939.)

(震研彙報 第十九號 圖版 永田)

Fig. 9 a. Crater bottom of Volcano Mihara. (Aug. 20, 1940.)

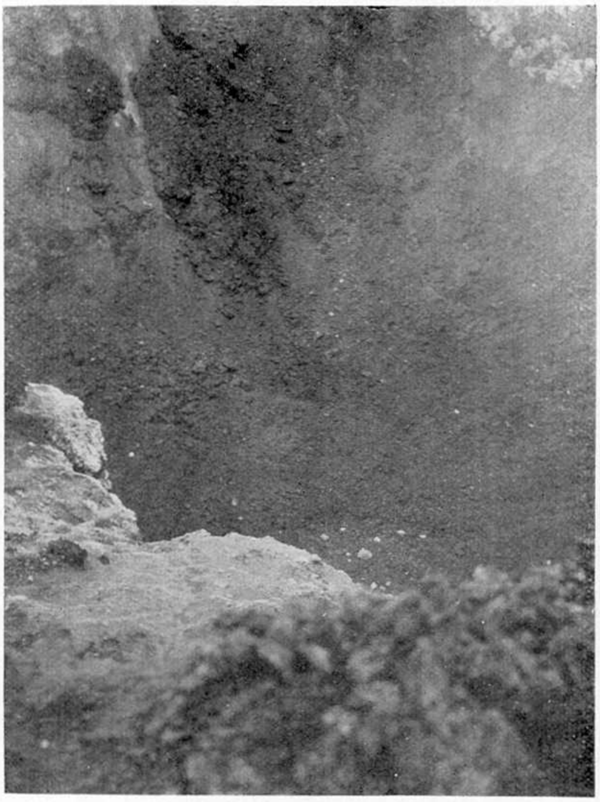

Fig. 9 b. Crater bottom of Volcano Mihara.
(Aug. 19, 1940.)

Fig. 10. Bomb newly ejected from Volcano Mihara. (Aug. 19, 1940.)

Fig. 11. Bomb and scoria newly ejected from Volcano Mihara. (Aug. 19, 1940.)