63. *Geophysical Studies of Volcano Mihara, Oosima Island; the General Aspect of Physical Conditions in the Crater.*

By Ryûtarô TAKAHASI and Takesi NAGATA,

Earthquake Research Institute.

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1. The results of the topographic survey of the crater of Volcano Mihara have been reported in the previous paper.[1] According to this survey, the present pit is almost conical in shape, being about 300 m deep measured from the top of the pit wall. Although the mean diameter of the pit was only 100 m at the time of S. Nakamura's survey in 1924 and 230 m by H. Tsuya's measurement in 1933, it is about 310 m at present. These results show that the mean diameter of the crater has increased linearly with time, as shown in Fig. 1. During the period from 1924 to the present (1937), there has been no marked activity of the volcano except incessant rumblings and volcanic earthquakes. The changes in the diameter of the pit may therefore be due to collapses of the crater wall owing to these rumblings and earthquakes, while the corrosion of the rocks forming the pit wall by the effect of volcanic vapours may be indirect, but it is at the same time the most important cause of these collapses.

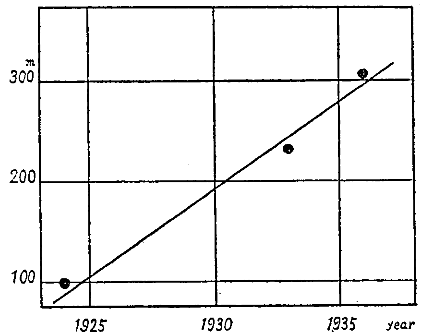


Fig. 1. Changes in the diameter of the crater of Mihara.

2. Since the changes in the topography of the interior of the pit, especially those in the depth, reflect most clearly the activity of the volcano, a re-survey of the topography of the interior of the pit was made in August, 1937. The method was exactly the same as that used in the previous case. By this re-survey it was found that the bottom of the pit has been covered with a sheet of newly formed solidified lava that flowed out probably during the minor activity of July 17, 1937.

1) R. TAKAHASI and T. NAGATA, *Bull. Earthq. Res. Inst.*, **15** (1937), 441.

Except for this lava sheet, no marked change in the general topography was found to have occurred since the time of the last survey (Nov., 1936). As will be seen from Figs. 2, 3, the new lava sheet has overspread the bottom in the shape of a platter, 65 m in diameter, the molten incandescent lava being visible beneath this solidified lava sheet through its cracks. The position of the largest of these cracks was determined with the same method as mentioned in the previous paper. In Table I the results of this determination are given for comparison,

Table I.

cracks	x	y	z
	m m	m m	m m
No. 1 (Nov. 1936)	+104·6±1·7	+91·7±1·8	−267·7±3·4
No. 2 (〃)	+ 95·1±1·4	+81·3±1·3	−289·4±2·7
Aug. 1937	+114·7±1·7	+92·5±1·3	−298·7±3·6

together with those of Nov., 1936. These values are referred to the same coordinates as those mentioned in the previous paper. Since these values show that there has been no marked changes in the depth of the pit during the last year, we may conclude that Volcano Mihara has been quiet, and is likely to remain so for a while, seeing that a marked rise of the pit bottom must invariably precede a severe eruption

Table II.

Reading of Current	No. of Lamp	Temperature	Condition
460 m.A.	No. 1	1020°C	Little Smoke
489	〃	1070	No Smoke
473	〃	1040	〃
498	〃	1095	〃
483	〃	1055	〃
483	〃	〃	〃
449	〃	990	Smoke
485	〃	1060	No Smoke
465	〃	1020	Little Smoke
430	No. 2	1010	〃
451	〃	1060	No Smoke
430	〃	1010	Little Smoke
439	No. 1	970	Smoke
458	〃	1010	Little smoke
465	〃	1020	〃

of this volcano,[2] just as it is the case with Asama.[3]

3. The temperature of the incandescent molten lava in the crater of a volcano is closely related to the activity of the volcano. Many reports have therefore been published on the temperature of the molten lava of such volcanoes as Vesuvius, Kilauea, Asama, Stromboli, etc. The writers measured the apparent temperature of the molten lava seen in the openings at the bottom of the pit of Mihara by means of a filament-disappearing-type pyrometer. To minimize the dispersion and absorption effects due to the emitting vapour, the measurement was made at night when there was very little or no vapour emission. These measurements are shown in Table II, in which "no smoke" means that no vadour could be seen anywhere in the whole crater, "little smoke" that the space from the bottom to the height of the shelf shown in Fig. 4 was filled with very light vapour, and "smoke" that the whole space of the pit was filled with the same very light vapour. These discontinuous changes in the conditions of the vapour are due to differences in the state of air circulation in the crater. The mean temperatures in these three states, "no smoke", "little smoke", and "smoke" were 1060°C, 1015°C, and 980°C respectively.

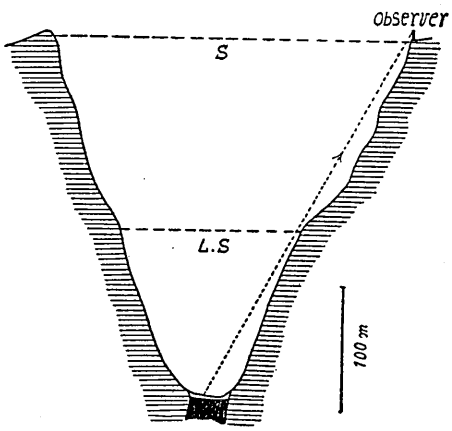


Fig. 4. Vertical section of the crater of Mihara.

To reduce the dispersion effects above mentioned to the minimum, the following calculations were made.

Assuming that the energy change dJ of the radiation emitted from the incandescent lava is proportional to the density of the vapour in the differential interval ds of the path from the lava to the observer, we have

$$dJ = -cJ\delta ds, \qquad \cdots\cdots\cdots\cdots(1)$$

where c is a constant. Integrating (1), we get

$$J = J_0 e^{-c\int_0^s \delta ds}, \qquad \cdots\cdots\cdots\cdots(2)$$

where J is the observed energy and J_0 the true energy emitted from

2) F. OMORI, *Rep. Earthq. Inv. Comm.*, No. 81 (1915).
3) T. MINAKAMI, *Bull. Earth. Res. Inst.*, **15** (1937), 492.

the radiant source. As the vapour seemed to be distributed almost uniformly in the space under investigation, in both cases of "little smoke" and "smoke" we assumed that the density δ of the vapour is always constant throughout the range where the vapour is present. Of course the ranges of integration with regard to s in these two cases differ from each other. If we take

$$c\delta=k,$$
$$J=J_0e^{-ks}, \tag{3}$$

where k is the coefficient of dispersion or absorption, and s the length of the part of the path of the radiation that is in the light vapour. As shown in Fig. 4, the lengths s are 160 m and 330 m in the cases of "little smoke" and "smoke" respectively.

Assuming further that the radiation process in our case follows Stefan-Boltzman's law, namely, $J=\sigma T^4$, we get the following relation from eqation (3):

$$4\log T=4\log T_0-ks, \tag{4}$$

where T and T_0 are the observed and true temperatures of the incandescent lava, both being expressed in the absolute temperature scale.

We shall now calculate the true temperature T_0 from our observations, which are fully shown in Table III. In determining the value

Table III.

Condition	T	S
No Smoke	1333°K (1060°C)	0 m
Little Smoke	1288 (1015 ″)	160
Smoke	1253 (980 ″)	330

of T_0, only the observed values of T that correspond to the two cases of "smoke" and "little smoke" were used. The observed temperature T in the case of "no smoke" was used only for checking the results of these determinations. The results thus calculated are

$$T_0=1335°K$$
$$k=0{\cdot}00037 \text{ per meter.}$$

The magnitude of T_0 calculated above exactly agrees with the observed values in the case of "no smoke". We may therefore feel assured that this temperature of 1060°C at the surface of the incandescent lava is not very far out.

The temperature determined by us seems to be slightly higher than that found by K. Fuji[4] in 1913, just after the last severe eruption of this volcano (when $T=890°\sim1010°C$). This discrepancy may be due rather to the changes in the effect of cooling by air on the surface of the hot lava than to changes in temperature of the lava itself, for the lava in our case is in the bottom of the cone-shaped crater, 300 m deep, the greater part of which is coverd with a solidified lava shell, whereas when K. Fuji made his observation the lava had been exposed to open air at the same level as the present crater mouth.

4. During our temperature observation, we noticed that a wavy deformation had formed on the surface of the incandescent lava accompanying the intermittent vapour discharges from the lava. The deformation, which is of wave form with respect to space, makes an aperiodic motion with respect to time. The wave length λ and the amplitude of the deformation were $1{\cdot}5\sim2{\cdot}2$ m and $0{\cdot}5\sim0{\cdot}7$ m respectively. The time interval τ, in which the amplitude of the elevation becomes 1/10 of the initial value, was observed to be $1{\cdot}8\sim2{\cdot}1$ sec.

Although we have not at present any reliable knowledge of the mechanism of formation of this wavy deformation nor of its characteristics, i.e. whether it is a diverging wave or a standing wave, it is certain that this deformation is due to the disturbances caused by the intermittent gas emission, and that the surface of lava thus deformed begins to return to its stable state as soon as the gas discharges cease.

Assuming that the deformation is a standing gravity wave in a viscous fluid, we shall now estimate the magnitude of the coefficient of viscosity of the incandescent lava. For simplicity, we shall treat it as a two-dimensional problem, taking the x-axis horizontally and the y-axis upwards.

The equations of motion and the condition of continuity are

$$\frac{\partial u}{\partial t}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\nu\nabla^2 u,\qquad \frac{\partial v}{\partial t}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\nu\nabla^2 v-g,\qquad \frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0,$$

where the notations u, v, p, ρ, t and g conform to the common usage[5] and ν donotes the kinetic coefficient of viscosity. If we take

$$u=-\frac{\partial \phi}{\partial x}-\frac{\partial \psi}{\partial y},\qquad v=-\frac{\partial \phi}{\partial y}+\frac{\partial \psi}{\partial x},$$

4) K. Fuji and T. Mizoguchi, *Proc. Tokyo. Math. Phys. Soc.*, 7 (1914), 243.

5) See Lamb, Hydrodynamics, 4th ed. p. 591.

$$\left.\begin{aligned} &\text{then} && \nabla^2\phi=0\,, \quad \frac{\partial^2\psi}{\partial t^2}=\nu\nabla^2\psi\,, \\ &\text{and} && \frac{p}{\rho}=\frac{\partial\phi}{\partial t}-gy, \end{aligned}\right\} \tag{5}$$

where
$$\nabla^2=\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}.$$

The solutions of equations (5) are

$$\phi=(Ae^{ky}+Be^{-ky})e^{ikx+\alpha t}$$
$$\psi=(Ce^{my}+De^{-my})e^{ikx+\alpha t}$$

where

$$m^2=k^2+\frac{\alpha}{\nu}.$$

In our case, $k=\frac{2\pi}{\lambda}$ is already given by the observation. We assume further that the depth of the fluid is infinitely large, and that the tangential and normal stresses at the free surface are zero, surface tension being neglected; whence

$$(p_{xy})_{y=0}=(p_{yy})_{y=0}=0.$$

Under these assumptions, we get the following relation after eliminating A, B, C, D;

$$(\alpha+2\nu k^2)^2+gk=4^2\nu k^3\sqrt{k^2+\alpha/\nu}\,. \tag{6}$$

Since in an extremely viscous fluid $\nu\gg1$, we get the following approximate relation from equation (6),

$$\alpha=-\frac{g}{2\nu k} \tag{7}$$

In our case $e^{-2\cdot0\alpha}=1/10$, and $k=2\pi/180$

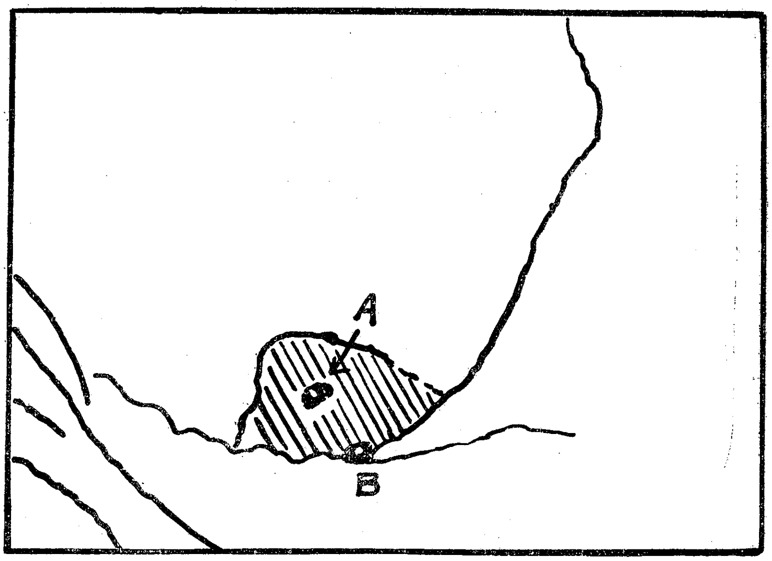
that is, $\alpha=1\cdot1$, $k=0\cdot035$.

Putting these values in equation (7), we get

$$\nu=1\cdot4\times10^4\ \text{gr./cm. sec.}$$

As the mean density ρ of Mihara lava is 3·0, the cofficient of viscosity becomes $\mu=\nu\rho=5\times10^4$ *C.G.S.*

The magnitude of the coefficient of viscosity thus obtained is near-



Newly ejected and solidified lava.

A,B. Clacks, through which incandescent lava is seen.

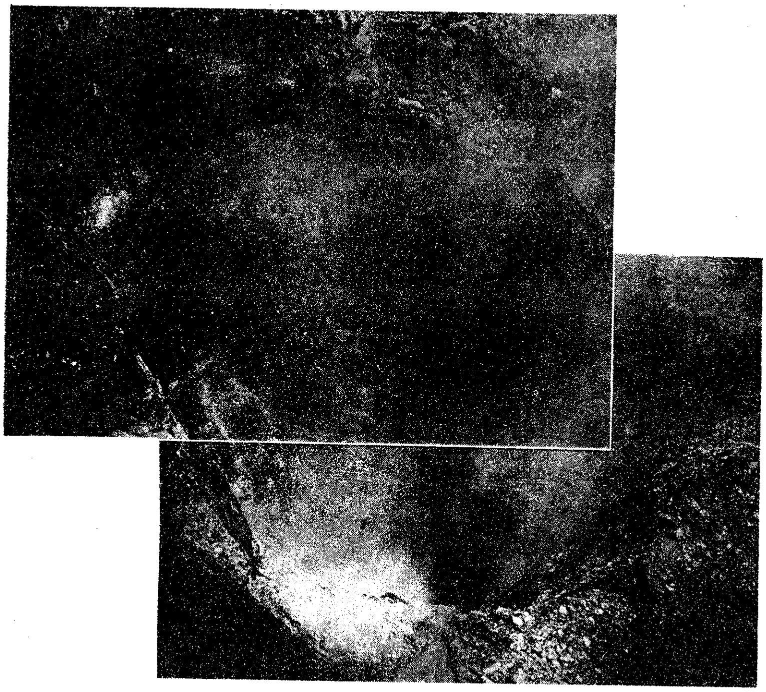


Fig. 2. The crater of Volcano Mihara.

Fig. 3. The bottom of the crater of Mihara.

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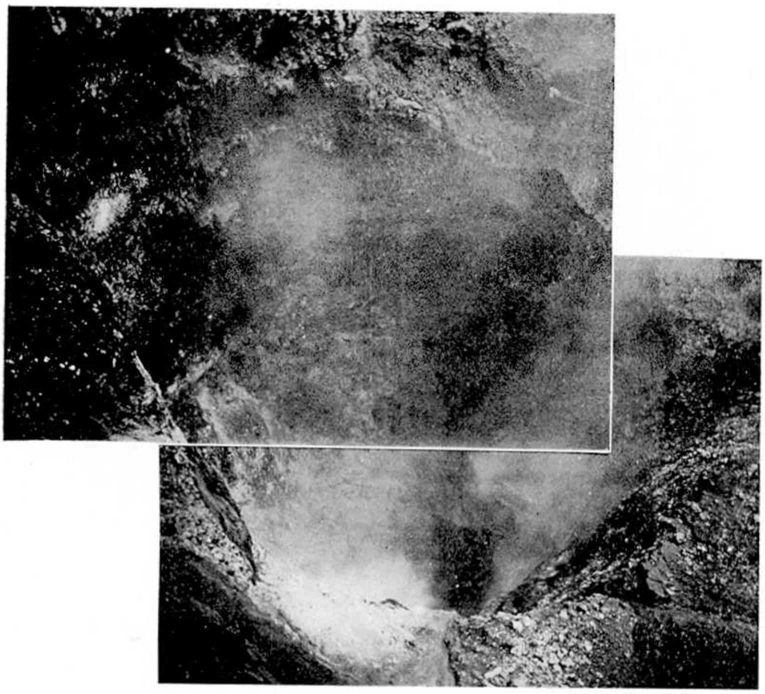

Fig. 2. The crater of Volcano Mihara.

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Fig. 3. The bottom of the crater of Mihara.

ly equal to that of "Miduame" at 20°C, as determined by N. Miyabe,[6] or to half of that of glycerine at 18°C.

The viscosity of the lava in the deeper part, however, will be smaller than this value obtained in the present study.

In conclusion, the writers wish to express their cordial thanks to the Hattori Hôkôkai for financial aid given, and to Prof. M. Ishimoto, the Director, for his interest in the present work.

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63. 伊豆大島三原火山の地球物理學的研究
火口内の物理的性質の概況

地震研究所 高橋龍太郎
永田武

1. 三原火山の火口内地形の再測を行つたが，1936 年 11 月の前測定から，今度の 1937 年 8 月の測定に至る間に於いては，火口底に新たな熔岩の噴出堆積があり，然も火口底は 10～20 m 程度深くなつた他には大した變化は見られない.

2. 赤熱熔岩の表面溫度を光學高溫計で測定し，その結果に水蒸氣の吸收による影響に對する補正をして $t=1060°C$ といふ値を得た.

3. 赤熱熔岩表面の定常的波動運動から，その粘性係數を計算して，$\mu=5\times10^4$ *C.G.S.* を得た. 之は 20°C に於ける水飴の粘性度に等しく Kilauea の熔岩の粘性より大いが內部に於いては更に粘性度の少い事が期待される. 之等の研究は服部報公會の援助によつて行はれつゝある三原火山の地球物理學的研究の一部であつて同會に對し深謝の意を表する.

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6) N. MIYABE, *Bull. Earthq. Res. Inst.*, **12** (1934), 199.