37. *Magnetization of the New Lava-Flows of Miyakesima Island.*

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Regarding the severe eruptions that occurred in Miyakesima Island, on the evening of July 12, 1940, detailed reports of the various volcanic phenomena, together with the results of observations by the members[1] of the Institute, appeared in previous Bulletins of our Institute.

On that occasion, the writer made magnetic surveys at 40 stations in the island in July and October, 1940, and in May, 1941.

In the course of this outburst, new lava-flows appeared at four places, the first from inside the somma and which flowed out from the central crater, the second and third at Akabakyo and Yoridai-sawa, where the lava flowed down from the present active fissure on the eastern slope of the mountain, and the fourth from the base of a new parasitic cone, Hyotan-yama.

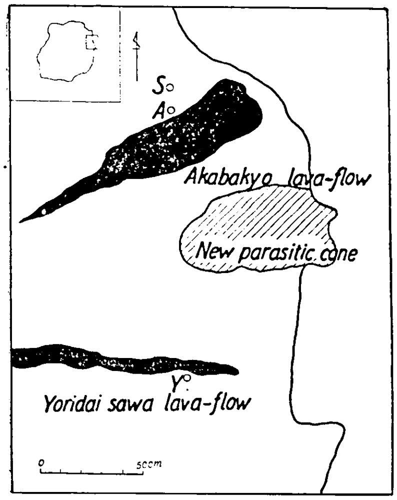

Fig. 1. Yoridai-sawa and Akabakyo lava-flows.
$Y, A, S,$= stations.

This paper deals with the variations in the magnetic dip near the Yoridai-sawa and Akabakyo lava-flows, and the intensity of magnetization of these lava-flows.

The locations and shapes of the two lava-flows, together with the stations for these magnetic observations, will be seen from Fig. 1 and Table 1.

The stations just mentioned were at distances of 6 m and 100 m from the northern margin of the Akabakyo lava-flow and 2 m from the southern margin of the Yoridai lava-

* Dedicated to the memory of his late respected teacher, Professor Mishio Ishimoto.

1) H. TSUYA and others, *Bull. Earthq. Res. Inst.*, **19** (1941), 260.

flow. The results of observations are shown, with their dates and hours in Tables II～IV and Figs. 2～4, from which will be seen the very remar-

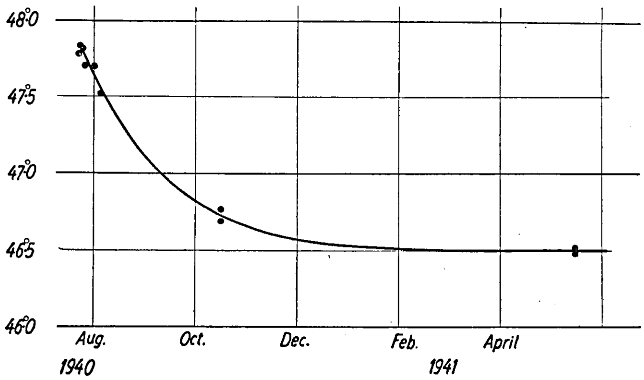

Fig. 2. Variations in dip at the Akabakyo station.

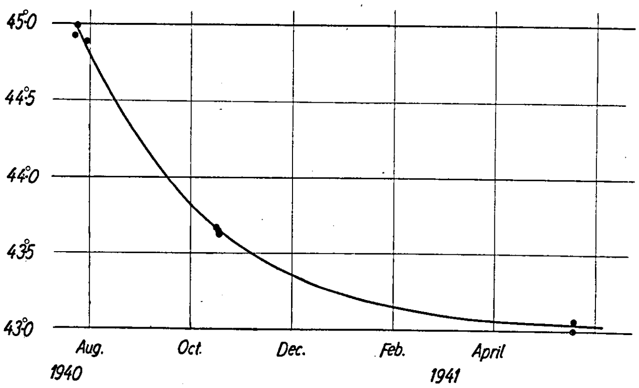

Fig. 3. Variations in dip at the Yoridai-sawa station.

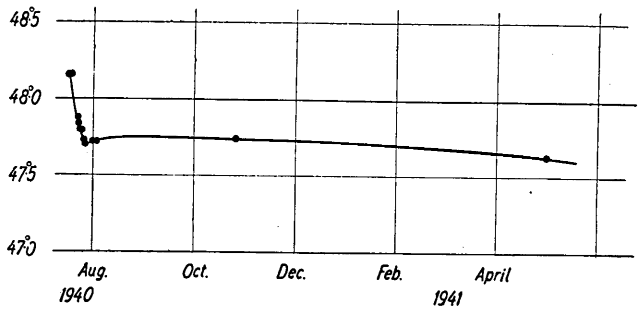

Fig. 4. Variations in dip at the Hodai station.

kable variations in the earth's magnetic field near the lava-flows during a period of only six months. These variations are a decrease of 1°

Table I.

lava-flow	mean width	mean depth	length
Akabakyo	200 m	7 m	500 m
Yoridai-sawa	20 m	6 m	1000 m

Table II. Results of Magnetic observations at the Yoridai-sawa station.

date	dip θ	variation $\Delta\theta$	$\Sigma\Delta\theta$
July 21, 1940	44° 56·′3	+4·′9	+4·′9
„ 22, „	45° 1·′2	−7·′0	−2·′1
„ 28, „	44° 54·′2	−1° 14·′8	−1° 16·′9
Oct. 25, „	43° 40·′8 }		
„ „ „	43° 39·′7 }		
„ „ „	43° 37·′9 }	−7·′9	−1° 24·′8
May 16, 1941	43° 31·′5 }		
„ „ „	43° 32·′3 }		

Table III. Results of Magnetic observations at the Akabakyo station.

date	dip (θ)	variation ($\Delta\theta$)	$\Sigma\Delta\theta$
July 21, 1940	47° 47·′0	+ 3·′4	+ 3·′4
„ 22, „	47° 50·′4	− 1·′3	+ 2·′1
„ 23, „	47° 49·′1	− 6·′6	− 4·′5
„ 25, „	47° 42·′5	− 0·′9	− 5·′4
„ 30, „	47° 41·′6	−10·′3	−15·′7
Aug. 3, „	47° 31·′3	−47·′4	−1° 3·′1
Oct. 14, „	46° 41·′5 }		
„ „ „	46° 46·′3 }		
May 16, „	46° 29·′3 }	−13·′5	−1° 16·′6
„ „ „	46° 31·′6 }		

Table IV. Results of Magnetic observations at the Sitori station.

date	dip (θ)	variation ($\Delta\theta$)	($\Sigma\Delta\theta$)
July 23, 1940	46° 28·′3	−13·′8	−13·′8
„ 25, „	46° 14·′5	−25·′2	−39·′0
„ 30, „	45° 49·′3	+ 0·′6	−38·′4
Aug. 3, „	45° 49·′9	+ 0·′1	−38·′3
Oct. 25, „	45° 50·′0	− 6·′8	−43·′1
May 15, 1941	45° 43·′2		

24′.8 at the Yoridai station and the same of 1° 16′.6 and 43′.1 at the Akabakyo and Sitori stations respectively.

On the other hand, resurveys of the magnetic dip at stations other than the four in the island during the period from July 14 to August 3, 1940, showed a decrease of from 20′ to 30′ at almost all these stations. These decreases in dip at the last mentioned stations appeared only during the first survey (1940) just referred to. That is, the variations in dip during the first survey and those in the second survey on October are less than 10′ at all the stations except the former three stations, namely, Akabakyo, Yoridai-sawa, and Sitori. As an example of variations in dip at a station situated some distance away from the lava-flows and undisturbed by the lava-flow, we give the results at the Hôdai station as shown Fig. 4. On the other hand, the variations in dip at the former three stations continued to May, 1941, although the rate of variation gradually diminished after October, 1940.

From these results, it may be resonable to conclude that the main part of the magnetic disturbances that appeared throughout the island, came to on end in July. 1940, the remarkable variations that appeared after August, 1940, at the three stations near the lava-flows being due to magnetization of the new lava-flows.

According to Nagata,[2] the temperature near the surface of the lava-flow at Akabakyo in July was 900°∼1000°. Since lava at such high temperature is scarcely magnetized, no magnetic desturbance from the lava-flow could appear even near it.

At the time of the third survey in May, 1941, the Akabakyo lava-flow cooled down to within 2 m of the surface, while in the Yoridai-sawa lava-flow the temperature of which was lower at the time of outflow than the former, cooled much more rapidly owing to the smaller quantity of lava-flow than the former.

Needless to say, therefore, before the temperature of the inner and outer parts of the lava-flow become equal, magnetization proceeds inward from the surface, as a consequence of which, magnetization of the lava-flow is not uniform, whence it may be reasonable to conclude that the characteristic variations in magnetic dip shown in Figs. 2 and 3 are the results of the condition just mentioned. It will be seen from Figs. 2 and 3 that the magnetization of the lava in May, 1941, remained almost unchanged.

Magnetic surveys of volcanoes[3] leave no room for doubt that

2) T. NAGATA, *Bull. Earthq. Res. Inst.*, **19** (1941), 295.
3) T. MINAKAMI, *Bull. Earthq. Res. Inst.*, **16** (1938), 100. 118; **18** (1940), 178; **19** (1941), 356.

magnetization of a comparatively new lava-flow is much more intense than other products of the volcano, such for example as the layer of scorie, pumice and ash. Moreover, Nagata's[4] laboratory work and the results of magnetic surveys of volcanoes showed that most lava-flows that have not been disturbed by the crustal deformation were magnetized in the direction of the earth's magnetic field at the time of ejection. It is probably only natural that a lava-flow that has cooled on the earth's surface from high temperature of about 1000°C should be magnetized in the direction of the earth's magnetic field. The writer's interpretation of the characteristics of the magnetic disturbance shown in Figs. 2 and 3, is based on this idea.

The Yoridai-sawa lava-flow runs from west to east, that is, the direction of flow is perpendicular to the magnetic meridian. Consequently in calculating the magnetization of the Yoridai-sawa, the lava-flow may be treated, without any serious objection, as a two dimensional problem. The origin of the co-ordinates is taken at the point where the observations were made, the x and z axes being taken in the magnetic north and downward. For convenience of computation, the lava-flow is divided into a large number of cylinders. The gravity potential of an infinite length of thin cylinder is

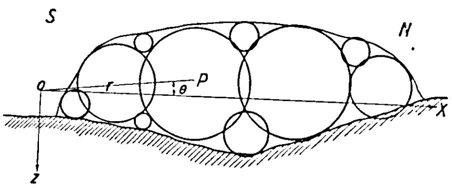

Fig. 5. Profile of the Yoridai-sawa lava-flow.

$$V=2\int_0^{\frac{\pi}{2}} \frac{k^2M\cos\varphi}{r}d\varphi=\frac{2Mk^2}{r}, \qquad (1)$$

where $M=\rho\pi a^2$, $\rho=2{\cdot}0$=mean density of lava-flow, a=radius of cylinder.

The second derivatives of the gravity potential of an infinite length of cylinder are

$$\left.\begin{aligned}\frac{\partial^2 V}{\partial x\partial z}&=4k^2\frac{M}{r^3}\sin\theta\cos\theta,\\ \frac{\partial^2 V}{\partial x^2}&=4k^2\frac{M}{r^3}\cos^2\theta,\\ \frac{\partial^2 V}{\partial z^2}&=4k^2\frac{M}{r^3}\sin^2\theta,\end{aligned}\right\} \qquad (2)$$

4) T. NAGATA, *Bull. Earthq. Res. Inst.*, **19** (1941), 304.

where k^2 = constant of gravitation.

The second derivatives of gravity potential of the lava-flow are

$$\left.\begin{aligned} W&=\sum V\,,\\ \frac{\partial^2 W}{\partial x\partial z}&=\sum\frac{\partial^2 V}{\partial x\partial z}\,,\\ \frac{\partial^2 W}{\partial x^2}&=\sum\frac{\partial^2 V}{\partial x^2}\,,\\ \frac{\partial^2 W}{\partial z^2}&=\sum\frac{\partial^2 W}{\partial z^2}\,,\end{aligned}\right\} \tag{3}$$

The variations in vertical and horizontal components of the dip due to magnetization of the lava-flow are given by the following equations:

$$\left.\begin{aligned} \varDelta H&=\frac{1}{k^2\rho}\left[\alpha\frac{\partial^2 W}{\partial x^2}+\gamma\frac{\partial^2 W}{\partial z\partial x}\right],\\ \varDelta Z&=\frac{1}{k^2\rho}\left[\alpha\frac{\partial^2 W}{\partial x\partial z}+\gamma\frac{\partial^2 W}{\partial z^2}\right],\\ \varDelta\Theta&=\sin\Theta\cos\Theta\left[\frac{\varDelta Z}{Z}-\frac{\varDelta H}{H}\right],\end{aligned}\right\} \tag{4}$$

where $\alpha=J\cos\Theta,\ \gamma=J\sin\Theta\,,$

J=mean intensity of the magnetization of lava,

$\Theta\doteqdot\frac{\pi}{4}$=magnetic dip near the lava-flow,

$H=Z=0{\cdot}32$ (C.G.S.) =horizontal and vertical components of magnetic intensity near the lava-flow.

The calculation gives

$$\left.\begin{aligned} \varDelta Z&=-0{\cdot}509J,\\ \varDelta H&=+1{\cdot}084J,\\ \varDelta\Theta&=-2{\cdot}330J.\end{aligned}\right\} \tag{5}$$

On the other hand, the variations in dip due to magnetization of the lava-flow is as given by the observations, is

$$\varDelta\Theta_0=-1°40'=-0{\cdot}0291 \tag{6}$$

The mean intensity of the magnetization of the lava-flow is determined from (5), (6), from which the variations in the horizontal and vertical components of magnetic intensity at the station work out as follows.

$$J = 0{\cdot}0124, \quad \Delta Z = -631\,\gamma, \quad \Delta H = +1350\gamma.$$

As to the magnetic disturbance due to the lava-flow, the variations in the magnetic dip at points upward 1 m from the lava-flow are shown in Fig. 6.

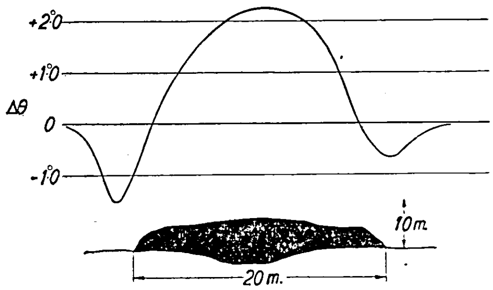

Fig. 6. Variations in dip on the Yoridai-sawa lava-flow obtained by calculation.

The mean intensity of magnetization of the Yoridai-sawa lava-flow as determined by the method above described agreed sufficiently well with that obtained by Nagata's laboratory experiments.

We may therefore conclude that the Yoridai-sawa lava-flow gradually cooled and was magnetized from the surface to the inner part of the lava-flow in the direction of the earth's magnetic field. The variations in dip at the Akabakyo and Sitori stations may reasonably be interpreted as the effects of the Akabakyo lava-flow. There is no doubt that the earth's surface near the stations tilted, owing to the weight of the lava-flow, but this effect on the variation of the magnetic field in the present case may be smaller than that due to magnetization of the lava.

In conclusion, the writer wishes to express his thanks to the Department of Education, with the aid of whose Scientific Research Encouragement Grant the present magnetic surveys were made possible.

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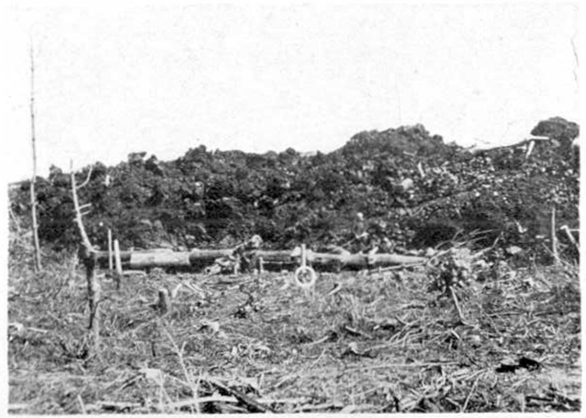
37. 三宅島新熔岩流の帶磁

地震研究所　水　上　武

昭和 15 年 7 月 12 日三宅島に著しい火山活動が起り，熔岩流の流出，寄生火山の成生等の火山現象が現はれた．その詳細は既に津屋博士其の他によつて報告されて居る．筆者は昭和 15 年 7 月，10 月，及び翌 16 年 5 月に同島に於いて磁氣伏角の測定を行つた．その際，ヨリダイ澤，赤場曉の新熔岩流の極めて近い點に於ける伏角の變動を測定し，熔岩の冷却と共に熔岩の帶磁の進行する狀況を知る事が出來た．即ち熔岩流は地球磁氣の方向に帶磁し，その強さ約 0·012 (C.G.S.) である事が判つた．

Yoridai-sawa lava-flow, and the station (○).



Akabakyo lava- ow, and the station (○).

Akabakyo lava-flow.

Akabakyo lava-flow.

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Akabakyo lava-flow.

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