10. Magnetic Surveys of Volcano Kusatu-Sirane.

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The Kusatu-Sirane volcano, Gumma prefecture, lies about 25 km from Asama, one of the most active volcanoes in Japan. Our Observatory of Volcano Asama, which is situated 4 km east of the crater of Asama, commands a view of the summit of Volcano Sirane, from which we may sometimes see the vapour issuing from Yugama, one of the craters on the summit of Volcano Sirane. The northern skirt of Asama and the southern foot of Sirane are bordered by the Agatuma river, the upper course of the Tone river, so that in some of the cliffs forming the banks of this river, one meets with layers of volcanic material traceable to these two volcanoes.

Although Volcano Sirane does not nowadays show any sign of activity, marked explosive activity manifested itself in October, 1932, on which occasion H. Tsuya,[1] notwithstanding the explosions near the crater, made personal observations and reported the results in the Bulletin.

In the volcanic phenomena displayed during explosions, the two volcanoes, Sirane and Asama, show a decided contrast. In the case of Asama, it is noticed that it throws out juvenile lava from the crater, and from the crater only, in the form of volcanic bombs and ash, while in the case of Sirane, it ejects ancient lava material that formed a part of the margin of the craterlets and fissures on the mountain slope, while no young lava are ejected from the crater nor from the fissures on the crater wall and the central cone. The history of volcanic activities of these two volcanoes shows that Asama enjoys a calm period almost regularly for 2 or 3 years after every similar period of continued activity, during which hundreds of explosions in all degrees of intensity occur, whereas of the activities of Volcano Sirane since historical times, we have only the following records.

1) H. TSUYA, *Bull. Earthq. Res. Inst.*, **11** (1933), 82.
Disin **4** (1932), (in Japanese).

(1) Aug. 6, 1882.

On the night of the 6th, an explosion in the interior of Yugama (water boiler) and its vicinity occurred with detonations and ejection of mud and ash, by which the trees and bushes on the peripheries and the margins of the craters, Yugama, Mizugama, and Karagama were completely destroyed. It is reported that as the result of this explosion, the water in Yugama rose in temperature and the water of Yumiike, a small crater lake, and of Mizugama exhibited changes in their chemical properties.

(2) July 8, 1897.

Since the latter part of May, detonations and earth-tremblings were noticed near the crater. They occurred in Yugama at the northeastern part of the center of the former explosion, with ejection of ash, which fell at Kusatu, distant 10 km E-SW from the crater.

July 31, 1897.

An explosion occurred in Yugama, ejecting numbers of large rocks about 160 kg to distances as 900 m. The activity lasted till Aug. 16, the same year.

(3) Oct. 1, 1900.

Activity reported, but without details.

(4) July 15, 1902.

The center of this activity was the northeastern part of Yumiike (see Fig. 1), instead of Yugama, the center of the former explosions, which was inactive and showed no signs out of the ordinary.

Aug. 20, 1902.

The second explosion occurred in the same part as the explosion of July 15, but less violently.

Sept. 4, 1902.

Explosions occurred near Yumiike and rained volcanic ash at Manza-Onsen, a hot spring, at its S-W foot, 3 km from the center of explosion.

Sept. 17, 1902.

An explosion occurred with detonations and ejection of rocks, and ashes which fell 2 km away. A column of black vapour shot up from the crater.

(5) Oct. 1905.

Explosions occurred in the hot-water pool in Yugama, and threw out large quantities of sulphur which fell into the Agatuma river.

(6) Jan. 22, 1925.

An explosion occurred in the northern part of Yugama, with ejection of rocks and ashes.

(7) Dec. 31, 1927.

Violent explosions occurred in the interior of Yugama and the southern slope of the present central cone. A remarkable phenomena accompanied the explosions in that the water in Yugama rose in temperature from 15°C to 24°C and its water level sank about 14 m.

(8) Oct. 1932.

On October 1, explosions occurred in the N-E part of the interior of the crater-wall of Yugama, and in the numerous fissures on the S-E slope of the central cone, that is, in a direction south of Yugama. This activity began 14h on October 1, and ended after the explosion at 9h on October 27, the same year. At the time of the first explosion, two workers in Yugama were killed and seven wounded by falling rocks.

As above described, the fact that the craterlets and fumaroles, that is, the centers of explosion, change with every volcanic activity, is one of the most outstanding characteristics of Volcano Sirane. In Fig. 1. are shown the movements of these centers of explosion.

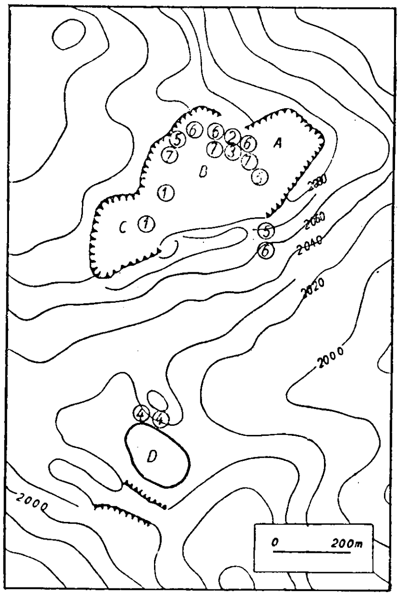

Fig. 1. Centers of explosions.

A; Mizugama. B; Yugama.
C; Karagama. D; Yumiike.
① Aug. 6, 1882.
② July 8, 1897.
③ Oct. 1, 1900.
④ July 15, 1902.
⑤ Jan. 22, 1925.
⑥ Dec. 31, 1927.
⑦ Oct. 30, 1932.

Dip Surveys.

Although geological and petrological studies of Volcano Kusatu-Sirane have been made by R. Ôhashi[2] and H. Tsuya,[3] nothing has yet been attempted from the geophysical point of view. Although as described above, the activity of Sirane is not so vioient as that of Asama, the study of the mechanism of explosion and the internal construction of volcanoes like that of Sirane is no less important and interesting than those of Asama. There is moreover the statement of the villagers of Asama and Sirane that the activities of the latter usually occurred when the former was in-

2) R. Ôhashi, *Bull. Imp. Earthq. Invest. Comm.*, (1913), (in Japanese)
3) H. Tsuya, *Bull. Earthq. Res. Inst.*, **12** (1933), 52.

active, so that, the existence of some geophysical relation between Asama and Sirane has to be considered. It is interesting to make clear the problem by the scientific method, seeing that the existence of some connections of lava-pits between Volcanoes Kilauea and Mauna-loa at Hawaii, is recognized by some volcanologists.

As the first step in studying Sirane from the geophysical stand-point, the author carried out magnetic dip surveys at 40 stations within and at the circumference of the present crater, during the period between August 19 and 28, 1937. The instrument was a dip circle of the Hydrographic Department, which is the same instrument that was used at Asama. Although such a survey cannot be executed for the time being on the crater floor of Asama, it was done at three stations on the crater-floor of Sirane, without any difficulty.

The results of the present observations are given in Tables I, II,

Table I.

Station	Height	Latitude	Longitude	Station	Height	Latitude	Longitude
1	1200 m	36°37′45″	138°35′48″	21	2150 m	36°38′87″	138°32′ 6″
2	1340	38′ 0″	35′ 6″	22	2120	38′34″	32′21″
3	1520	38′18″	34′11″	23	2080	38′25″	32′25″
4	1700	38′45″	33′37″	24	2090	37′22″	32′27″
5	1825	39′ 3″	33′ 9″	25	2040	37′47″	32′13″
6	2085	38′34″	32′31″	26	2050	38′42″	32′15″
7	2080	38′11″	32′ 9″	27	2090	38′29″	32′22″
8	2060	38′22″	32′ 8″	28	2010	38′45″	32′39″
9	2060	38′26″	32′17″	29	1930	38′50″	32′55″
10	2060	38′25″	32′15″	30	1850	38′52″	33′ 8″
11	2075	38′16″	32′19″	31	1760	38′22″	30′53″
12	2120	38′24″	32′11″	32	1940	38′19″	31′22″
13	2085	38′21″	32′25″	33	2040	38′14″	31′49″
14	2045	38′17″	32′15″	34	1740	38′18″	30′50″
15	2030	38′ 5″	32′10″	35	1835	39′ 7″	33′14″
16	1940	38′27″	32′55″	36	1980	37′11″	32′42″
17	1990	38′22″	32′54″	37	1950	37′48″	33′12″
18	2080	37′56″	32′18″	38	1860	37′14″	33′22″
19	2140	38′32″	32′ 1″	39	1470	37′32″	34′30″
20	2160	38′29″	31′53″	40	1300	37′12″	35′28″

with the situations of the stations and the date and times of observation. The isoclinic lines near the crater, together with the contours, are given in Fig. 2, a glance at which shows the remarkable effects of

Table II.

Station	Date	Time	Dip (θ_i)	Anomaly ($\Delta\theta_i$)
1	July, 19	$8^h 50^m$	49° 58′·3	+ 1′·5
2	〃	9 45	49° 59′·2	+ 2′·4
3	〃	10 49	50° 11′·1	+ 14′·3
4	〃	12 29	52° 23′·9	+2° 27′·1
5	〃	14 00	50° 12′·7	+ 15′·9
6	〃	15 21	50° 19′·0	+ 12′·2
7	July, 20	8 34	50° 2′·3	+ 5′·5
8	〃	9 14	49° 17′·4	− 39′·4
9	〃	10 4	49° 7′·2	− 49′·6
10	〃	11 10	48° 53′·5	−1° 3′·3
11	〃	12 43	50° 16′·3	+ 9′.5
12	〃	13 39	51° 4′·3	+1° 7′·5
13	July, 21	8 51	50° 7′·4	+ 10′·6
14	〃	9 40	49° 40′·3	− 16′·5
15	〃	10 28	49° 42′·9	− 13′·9
16	〃	12 6	49° 55′·1	− 1′·7
17	〃	13 10	50° 16′·3	+ 19′·5
18	〃	14 18	49° 55′·0	− 1′·8
19	July, 23	8 28	50° 55′·7	+ 58′·9
20	〃	9 17	50° 23′ 2	+ 26′·4
21	〃	10 1	50° 4′·9	+ 8′·1
22	〃	10 45	49° 40′·7	− 16′·1
23	July, 24	9 40	49° 53′·3	− 3′·5
24	〃	10 21	50° 29′·0	+ 32′·2
25	July, 23	12 58	49° 25′·6	− 31′·2
26	〃	13 44	48° 50′·3	−1° 6′·5
27	July, 24	9 00	50° 38′·1	+ 41′·3
28	〃	11 15	49° 52′·5	− 4′·3
29	〃	12 12	50° 24′·3	+ 27′·5
30	〃	12 53	50° 11′·1	+ 14′·3
31	July, 22	7 41	49° 15′·6	− 41′·2
32	〃	8 45	49° 36′·6	− 20′·2
33	〃	9 44	49° 34′·3	− 22′·5
34	〃	10 55	49° 21′·9	− 34′·9
35	July, 24	13 39	49° 46′·2	− 10′·6
36	July, 26	8 43	49° 59′·3	+ 2′·5
37	〃	9 39	49° 38′·3	− 18′·5
38	〃	10 41	49° 24′·4	− 32′·4
39	〃	11 19	49° 37′·3	− 19′·5
40	〃	12 22	49° 28′·4	− 28′·4

topography, while the values of the dip increase with the height of the station. In addition, the results of the present surveys show that the

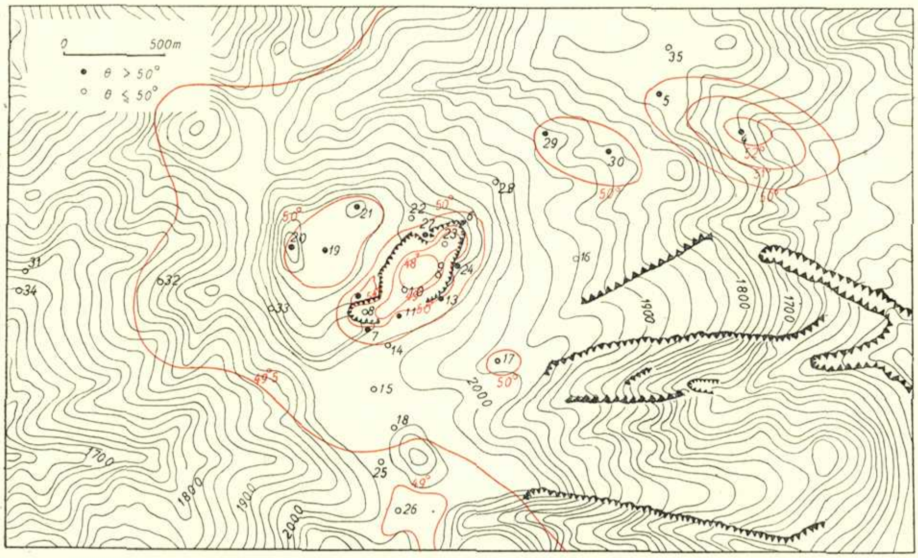

Fig. 2. Isoclinic lines.

values at stations situated higher than 2000 m above sea level, mostly exceed 50°, whereas the values on the crater-floor are very much smaller although their heights are more than 2000 m above sea level, being greatly affected by the abnormal topography. The dips at 11 stations situated on the crater floor and on the margin of the crater are connected with the heights of the stations with the following relations. (see Table III and Fig. 3.)

$$\theta'_0 = \frac{\Sigma \theta'_i}{n}, \qquad \Delta\theta'_i = \theta'_i - \theta'_0$$

$$h'_i = \frac{\Sigma h'_i}{n}, \qquad \Delta h'_i = h'_i - h'_0$$

$$\begin{pmatrix} n = 11 \\ i = 1, 2, \ldots\ldots 11 \end{pmatrix}$$

where

θ'_i; dip at stations on the crater-floor and on the margins, of the crater-wall,

θ'_0; mean dip,

h'_i; height above sea level of the stations above mentioned,

h'_0; mean height.

Table III.

Station No.	Dip. (θ_i)	Height of Station (h_i)	$\Delta\theta_i$	Δh_i
6	50° 19′·0	2085 m	+18′·4	+10 m
7	50° 2′·3	2080	+ 1′·7	+ 5
8	49° 17′·4	2050	−43′·2	−25
9	49° 7′·2	2040	−53′·4	−35
10	48° 53′·5	2040	−67′·1	−35
11	50° 16′·3	2098	+15′·7	+ 3
12	51° 4′·3	2120	+63′·7	+45
13	50° 7′·4	2085	+ 6′·8	+10
23	49° 53′·3	2080	− 7′·3	− 5
24	50° 29′·0	2090	+28′·4	+15
27	50° 38′·1	2095	+37′·5	+20

mean $\theta_0=50°$ 0′·6 mean $h_0=2075$ m

In Fig. 3, the linear relation between $\Delta\theta_i$ and Δh_i is that as seen at Asama.

Of the dips of 40 stations, the maximum and the minimum are 52° 23′·9 at station 4 at Yosinotaira and 48° 50′·3 at station 28 on the crater-floor. The mean dip of these 40 stations is as follows.

$$\theta_0=\frac{\Sigma\theta_i}{n}=49° \quad 56'{\cdot}8$$

$$\varphi_0=\frac{\Sigma\varphi_i}{n}=36° \quad 38'.1$$

$$\lambda_0=\frac{\Sigma\lambda_i}{n}=138° \quad 33'{\cdot}1$$

$$\left(\begin{array}{l} n=40 \\ i=1,\ldots\ldots 40 \end{array}\right.$$

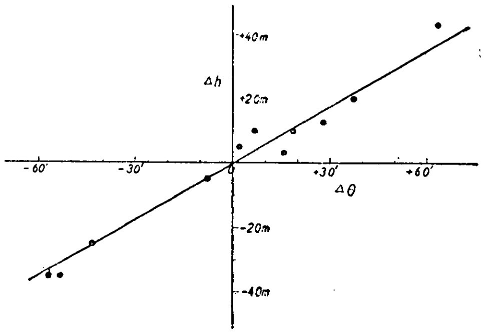

Fig. 3. Dip anomalies near the craters.

where φ_0, λ_0 are the mean latitude and longitude of the 40 stations. The value of the dip corresponding to the mean latitude and the longitude (φ_0, λ_0) calculated from the quadratic equation determined by the Hydrographic Department, is 50° 15′·3 The calculated value is 18′·5 in excess of the mean observed value, which tendency is the same as that at Asama.

$$\Delta\theta_i=\theta_i-\theta_0$$

For our purpose, the remainders ($\Delta\theta_i$) above defined are called here dip anomalies. From the distribution of these dip anomalies with reference to the topography, it is clear that there is an intimate corelation between the dip and the topography around the station, that is, the isoclinic lines and the iso-anomaly lines are parallel to the contour lines.

Although an outline of the magnetic character of Volcano Kusatu-Sirane has been obtained by the present surveys, one of our main objects was to bring out clearly the time variations in the magnetic changes that accompany volcanic activity, so that in order to facilitate resurveys, the stations where the present surveys were made have been marked by posts driven into the ground. It is hoped to repeat the magnetic surveys and other geophysical studies of Volcano Kusatu-Sirane.

In conclusion, the author wishes to express his hearty thanks to the Hydrographic Department for the loan of the dip circle. He also acknowlgdges his great indebtedness to the Foundation for the Promotion of Scientific and Industrial Research of Japan, with whose grant this study was made possible.

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10. 草津白根火山の磁氣測量 (共の 1)

地震研究所 水 上 武

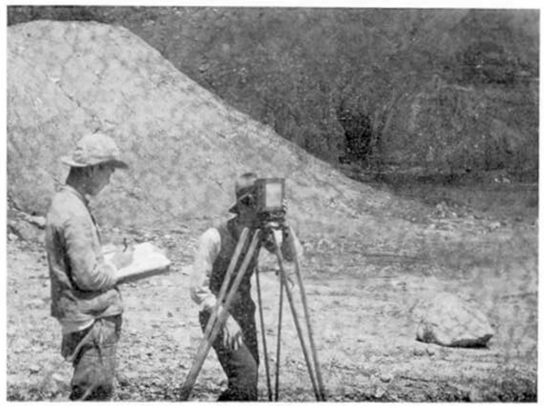
草津白根火山は淺間火山の北約 25 粁の位置にあり，淺間火山に最も接近せる活火山である．今回草津白根火山の地球物理學的研究の第一步として，火口内外 40 點に於いて磁氣伏角の測定を行ひ，白根火山の磁氣の狀態，並に火山活動に伴ふ磁氣變化を明かにせんと企てた．2, 3 年後或は火山活動後に再測し度いと考へて居る．今回の測定を施行するに當り伏角計の使用を許可された海軍水路部に對し，尙又日本學術振興會の補助により測定を行ひ得た事に對し，共に厚く感謝の意を表す．

[Bull. Earthq. Res. Inst., Vol. XVI, Pl. VII.]

Station 5, Yosinotaira.

Station 8, Karagama.

Station 9, Yugama.



Station 10, Yugama.

(震研彙報 第十六號 圖版 水上)