Volcanothermal Investigation of Active Crater : Temperature variation in the bottom ground of the Naka-dáke crater of the Aso volcano

Taneda, Sadakatu
Faculty of Science, Kyushu University

https://doi.org/10.5109/1543584

出版情報：九州大學理學部紀要 : Series D, Geology. 14 (1), pp.23-38, 1963-01-30. Faculty of Science, Kyushu University

Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol., Vol. XIV, No. 1,
pp. 23-38, tables 1-5, text-figs. 1-12, January 25, 1963

Volcanothermal Investigation of Active Crater

—Temperature variation in the bottom ground of the Naka-dáke crater of the Aso volcano—

By

Sadakatu TANEDA

Most petrologist and volcanologist would be very interested in the thermal studies of magma, and during the studies they would desire to know the relationships between the mode of temperature variation in the bottom ground of active crater and other volcanic phenomena (tremor, earthquake, variation of magnetism, gravity, etc.), because the relationships may vary depending upon the processes involved and properties of the magma, by which the energy of volcanic eruption developes. In addition, as to the prediction of volcanic events the thermal investigation of the active crater seems to be very important.

It has long been desired to measure continuously the temperature variation of the volcanic jet and bottom ground of active crater, even though there are difficulties in dangerous work at the bottom of the active crater, measurement techniques** and economical conditions.

I am very pleased to give here the results of measuring the temperature variation in the bottom ground of the Naka-dáke crater, which has been perhaps the only active crater in Aso throughout historic times. The crater is oblong in form, constructed of several smaller craters combined, which are called the 1st, 2nd, 3rd, etc. successively from N to S. Since 1933, the 1st crater, about 500 m in diameter and 110 m in depth, has been active with intermittent small explosions (KAWANO 1934, TANEDA & MATSUMOTO 1954, TANEDA *et al.* 1959). After the distinct explosion occurred on the 24th of June, 1958, I succeeded in beginning the continuous measurement of the temperature of the bottom ground in the 1st crater with thermistors at two points: one (N) is situated by an explosion hole (crater pit) of June 24, 1958, and the other (S) at the southern wall. The two measurement points are approximately 120 m apart (Fig. 2).

The thermistor (Hitati thermistor C_{33}) inserted into a vacuum glass tube covered with an iron tube of 1.6 m length were burried vertically 1 m deep

* Received October 5, 1962.

** Especially it is difficult to protect the apparatus from the destructive eruptions and strongly corrosive volcanic jet with high temperature.

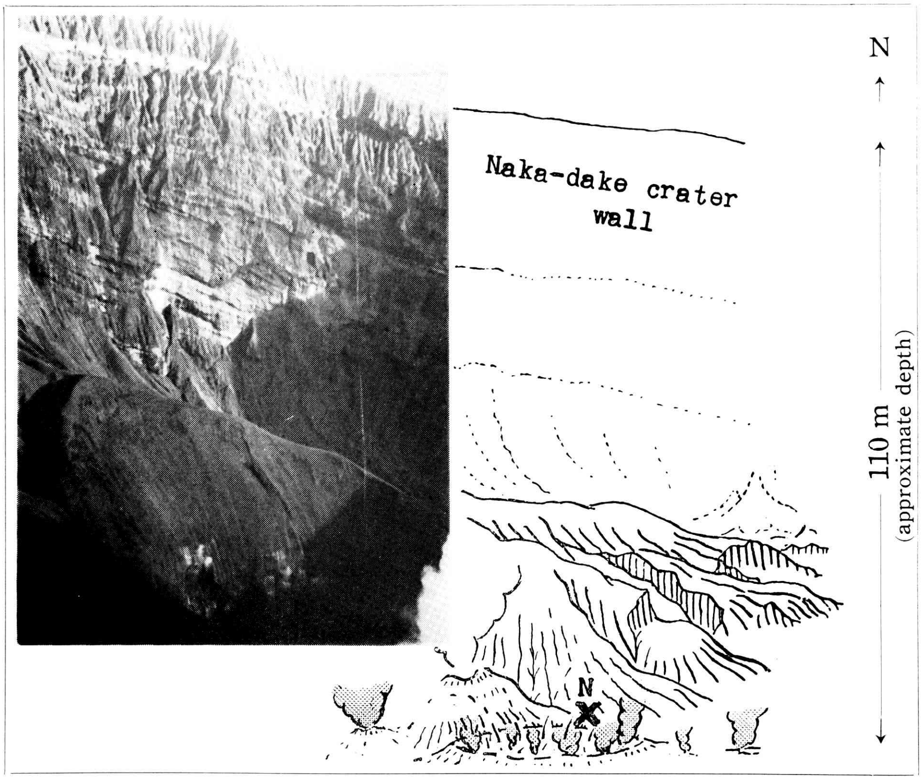

Fig. 1. Locality of the observation point (N) on the rim of an explosion hole (crater pit) in the Naka-dáke crater (1). Ref. to Fig. 2.

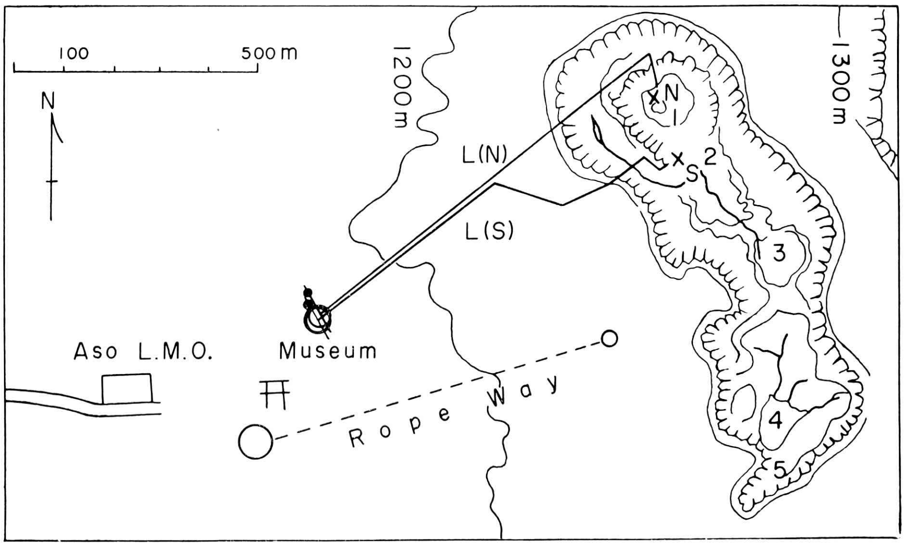

Fig. 2. The Naka-dáke crater (1, 2, 3, 4, 5) and the measurement system (N & S: measurement points, L(N) & L(S): electoric lines connecting the measurement points and the indicators.)

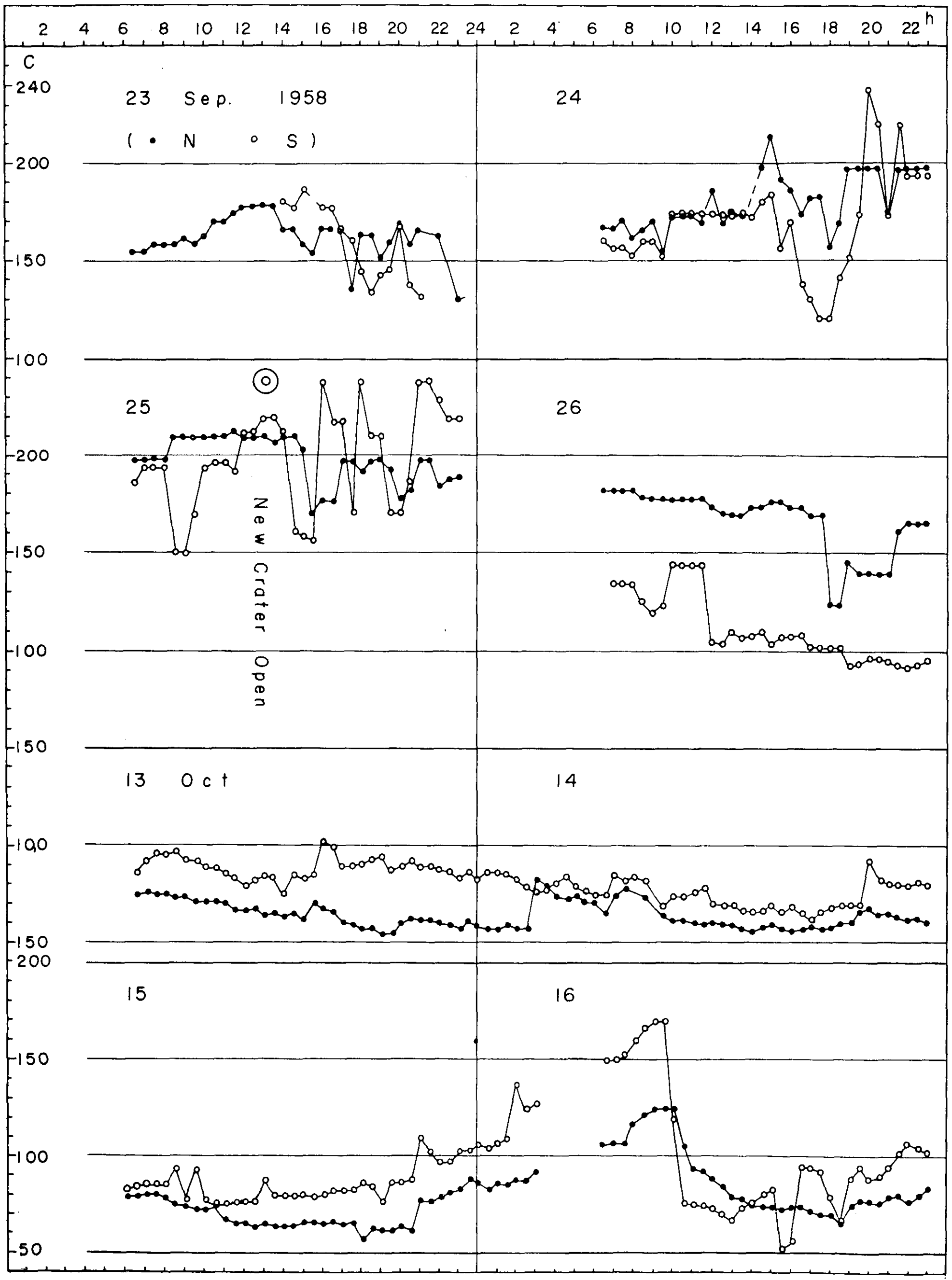

Fig. 3. Temperature variation at points N and S.

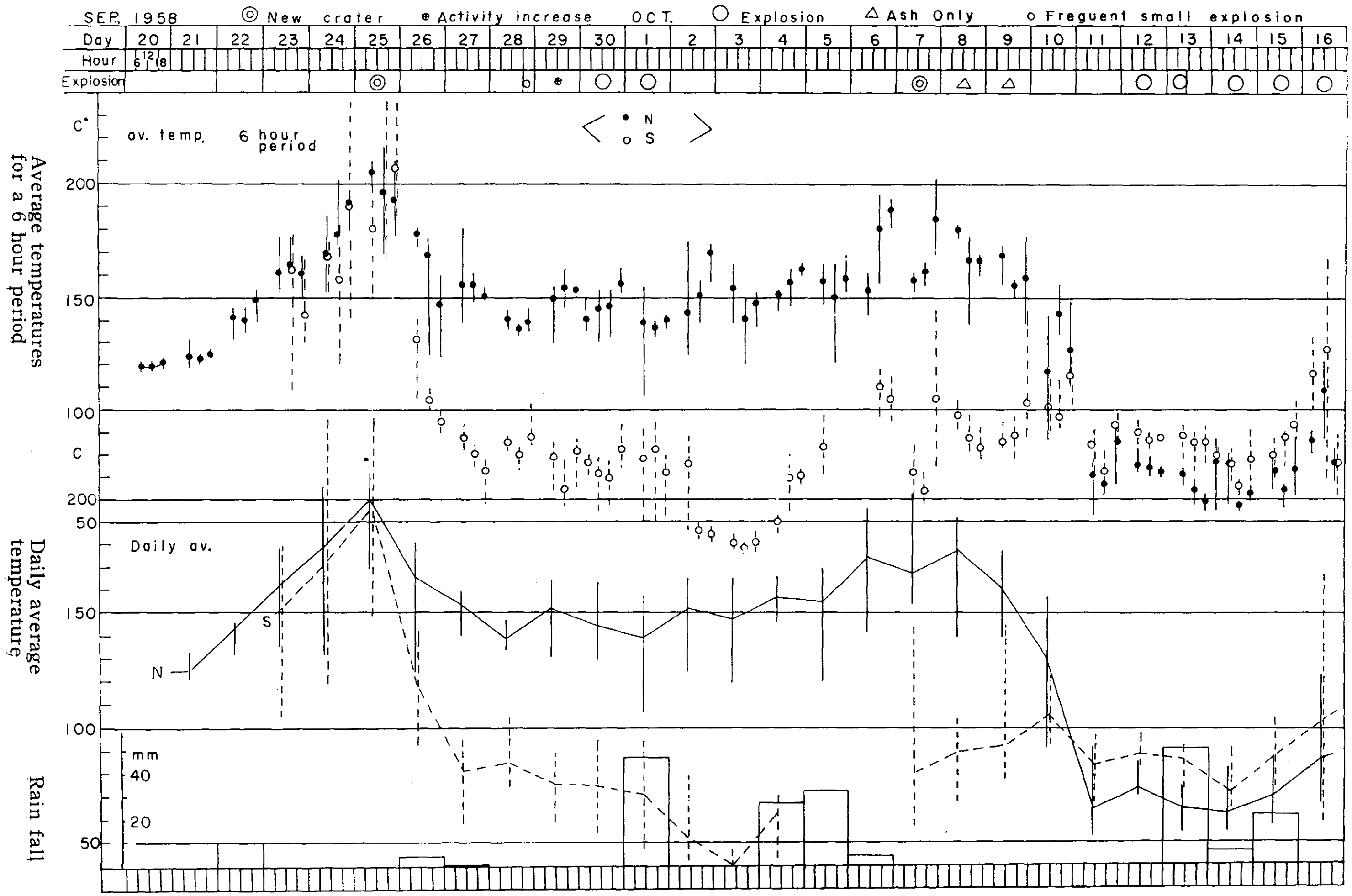

Fig. 4. The temperature variation in the bottom ground and surface action of Naka-dåke crater of the Aso volcano, and rain fall at the Aso L.M.O.

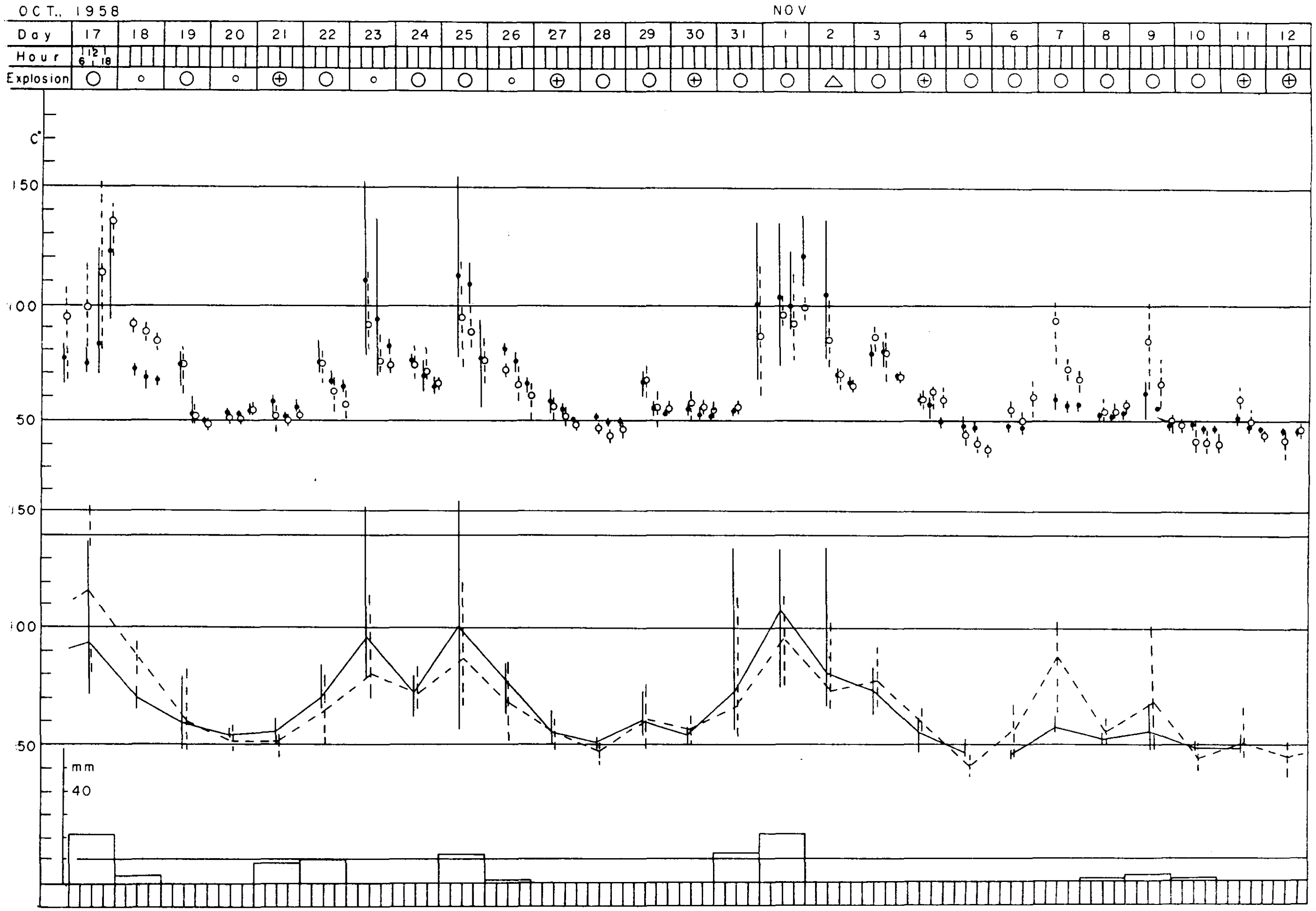

Fig. 5. The temperature variation in the bottom ground and surface action of Naka-dáke crater of the Aso volcano, and rain fall at the Aso L.M.O.

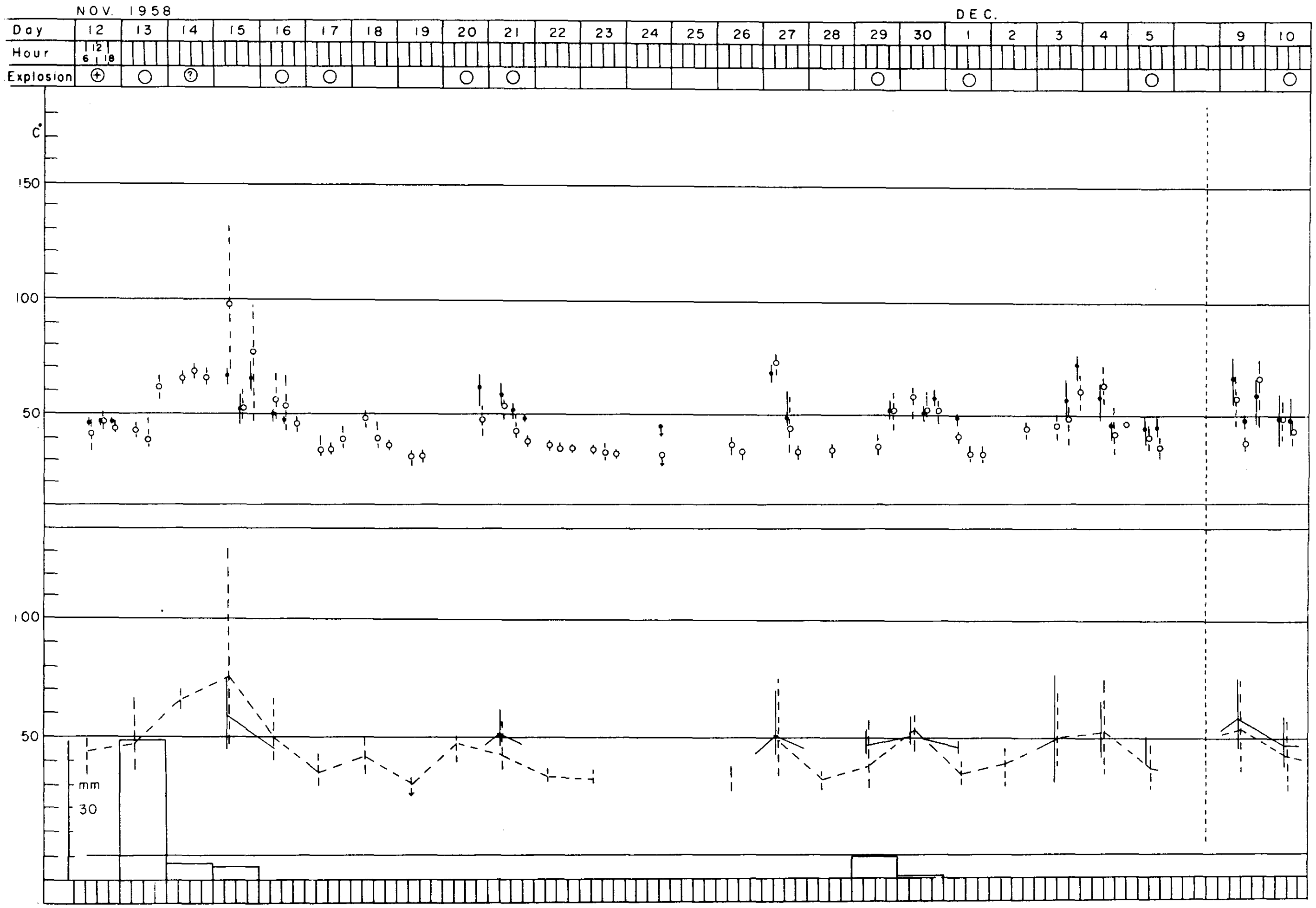

Fig. 6. The temperature variation in the bottom ground and surface action of Naka-dáke crater of the Aso volcano, and rain fall at the Aso L.M.O.

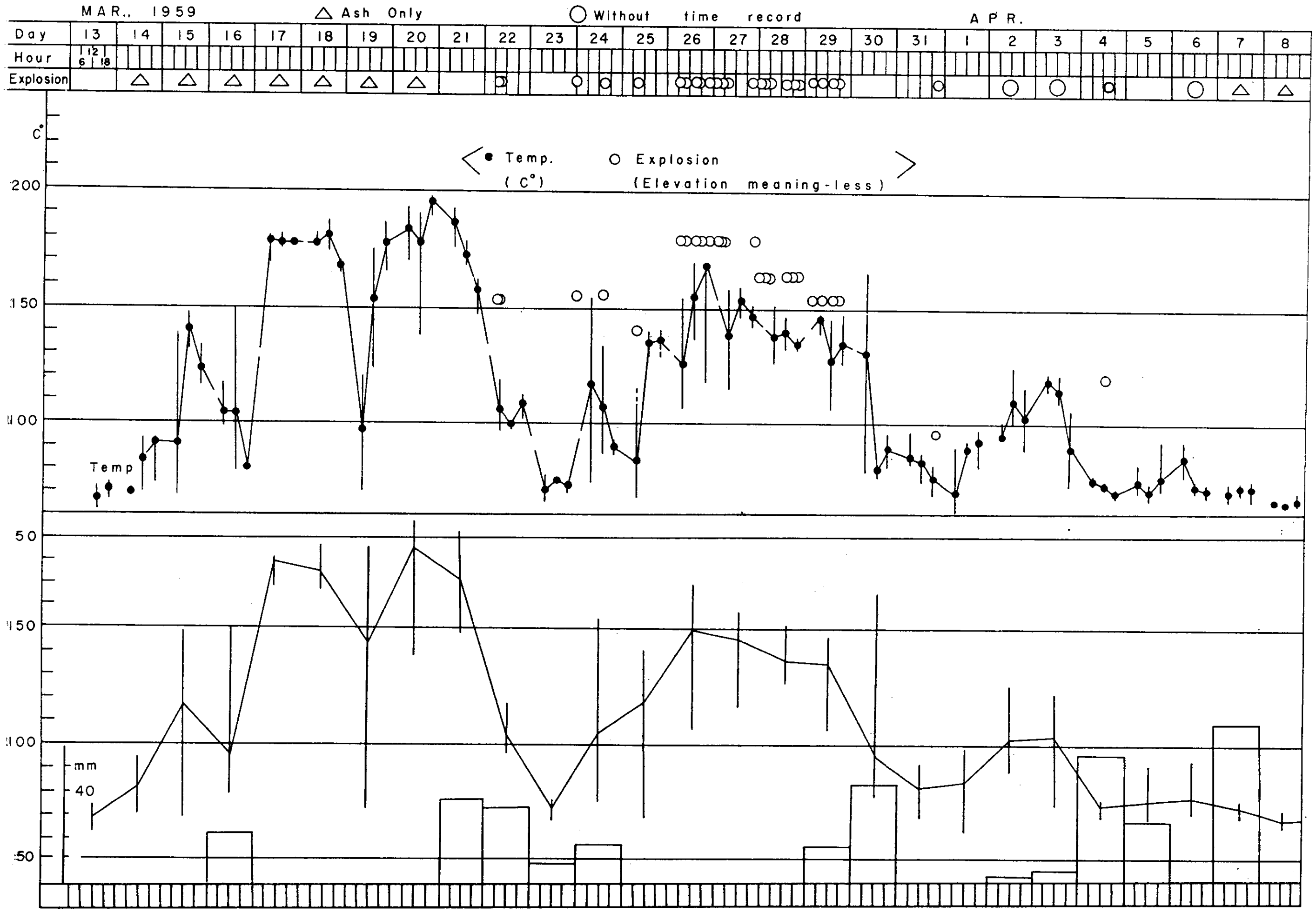

Fig. 7. The temperature variation in the bottom ground and surface action of Naka-dâke crater of the Aso volcano, and rain fall at the Aso L.M.O.

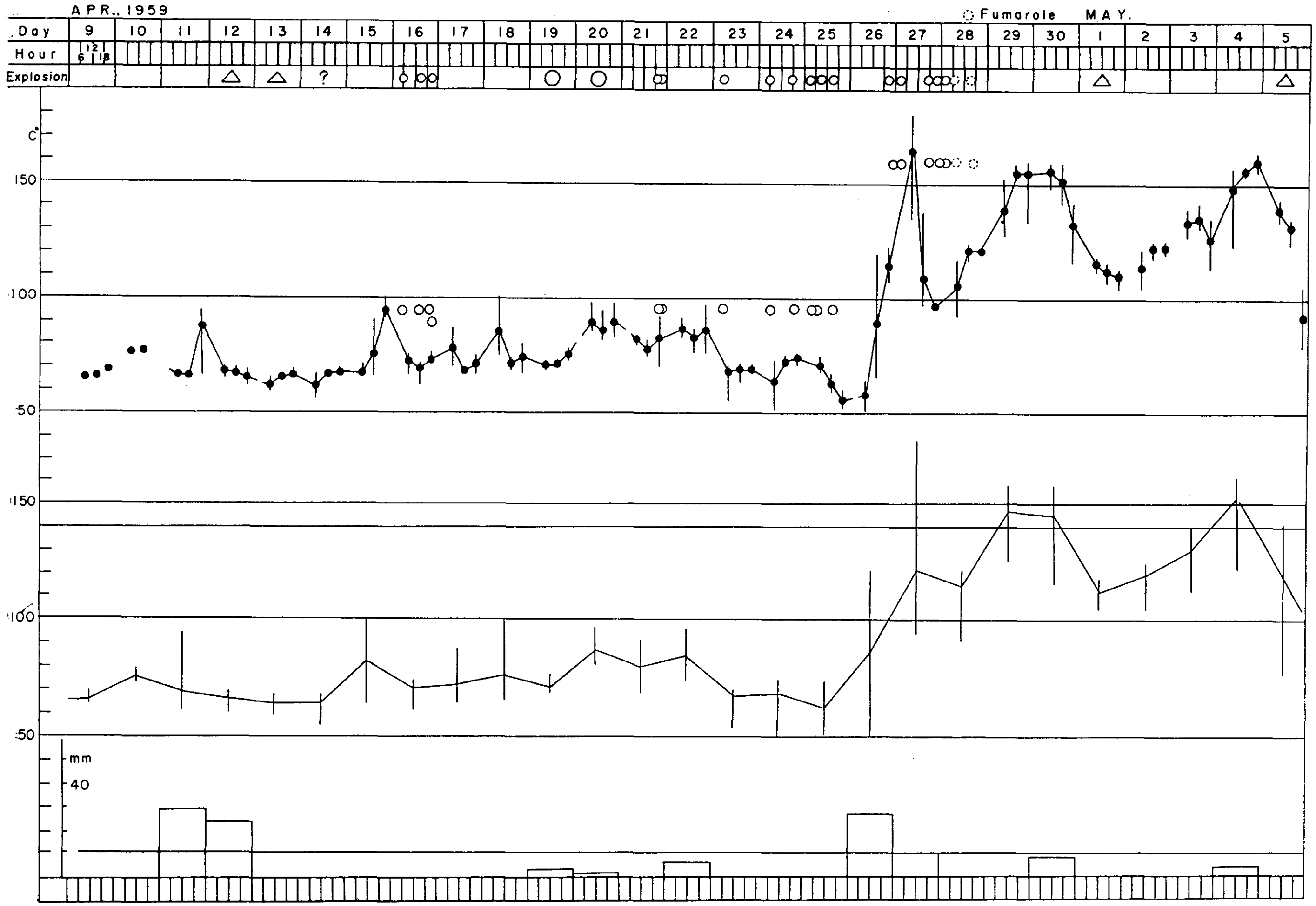

Fig. 8. The temperature variation in the bottom ground and surface action of Naka-dáke crater of the Aso volcano, and rain fall at the Aso L.M.O.

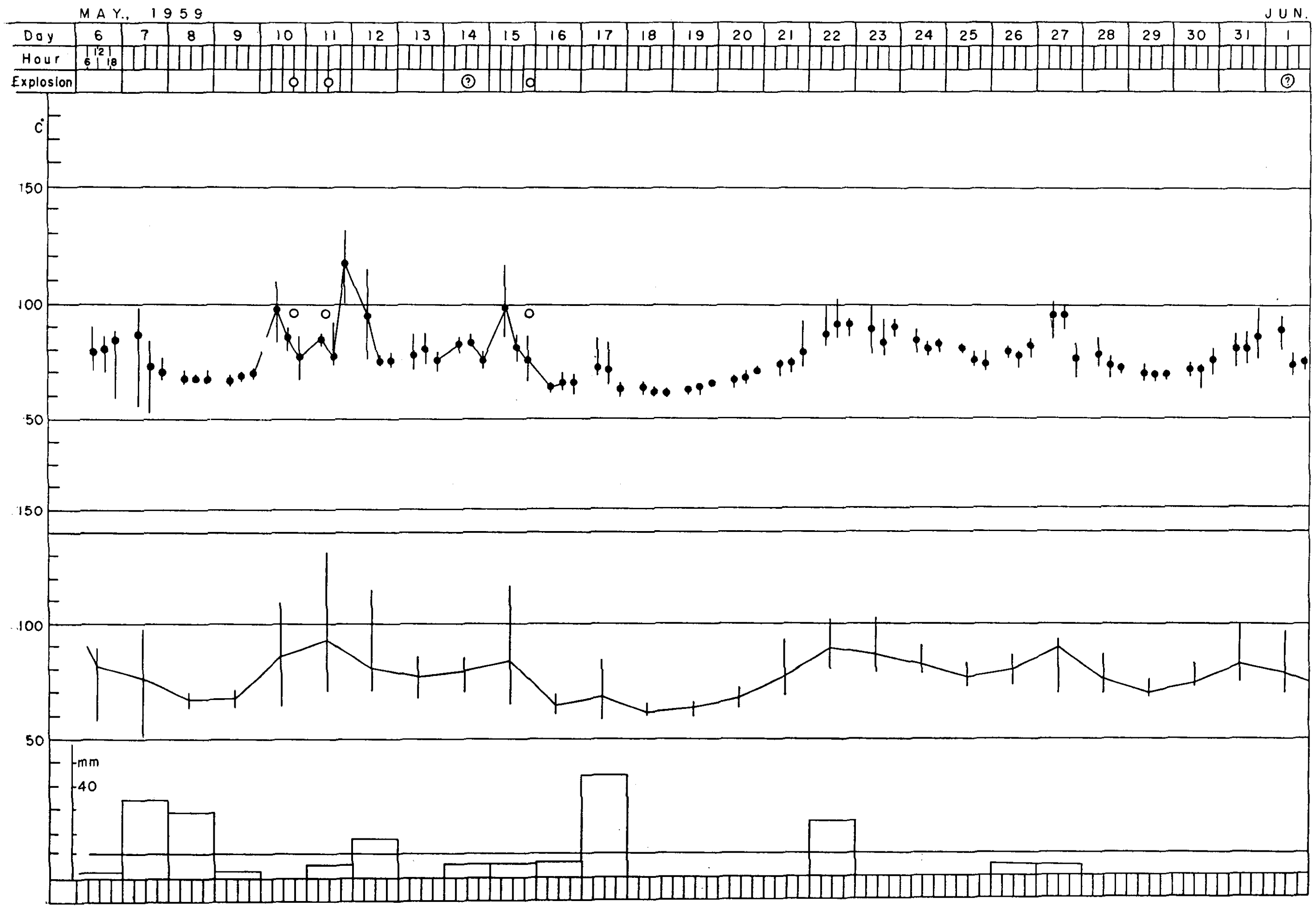

Fig. 9. The temperature variation in the bottom ground and surface action of Naka-dáke crater of the Aso valcano, and rain fall at the Aso L.M.O.

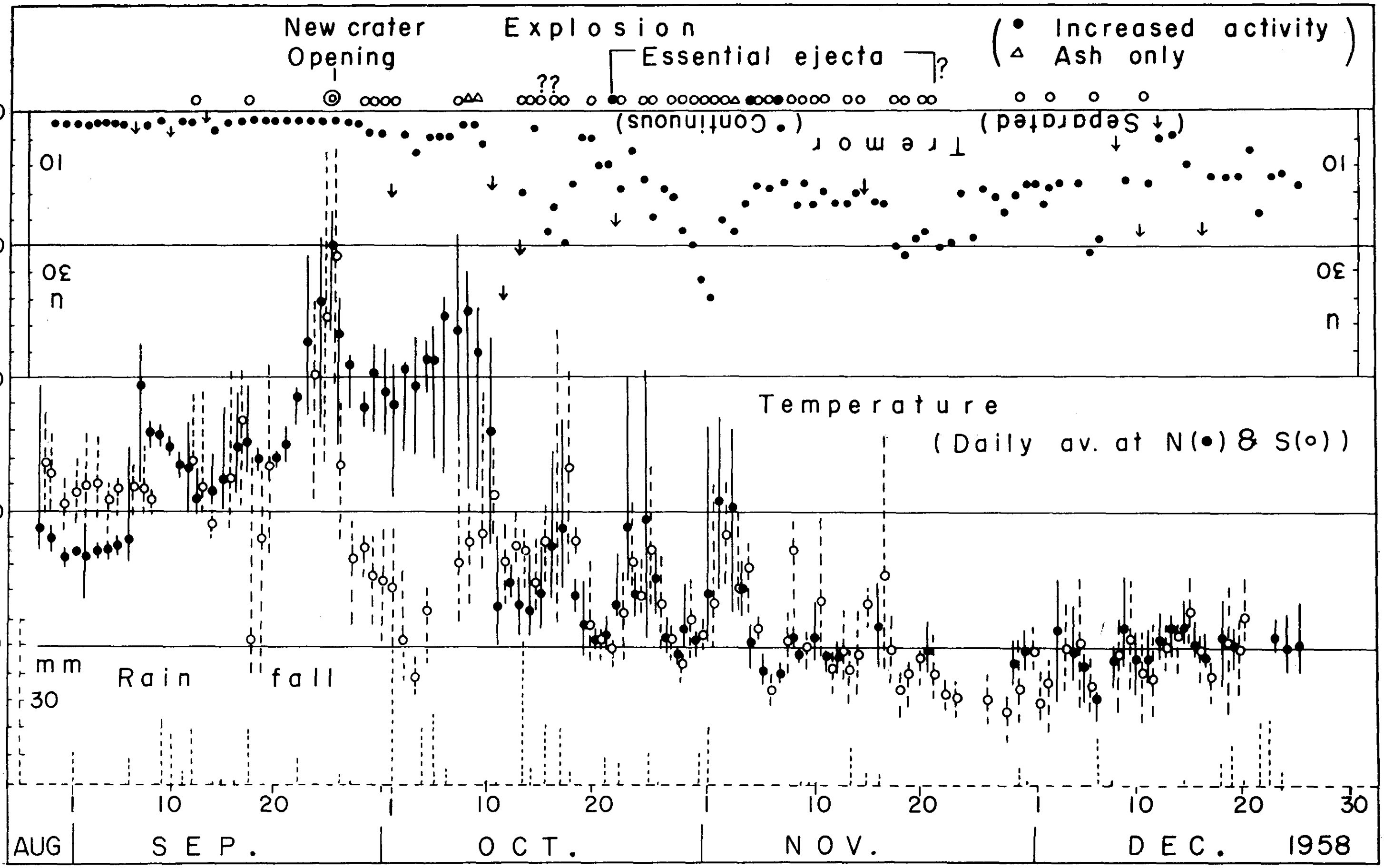

Fig. 10. Variation of the temperature, tremor and surface action of the Naka-dáke crater and rain fall at the Aso L.M.O. The data of tremor and rain fall were given by the Aso L.M.O.

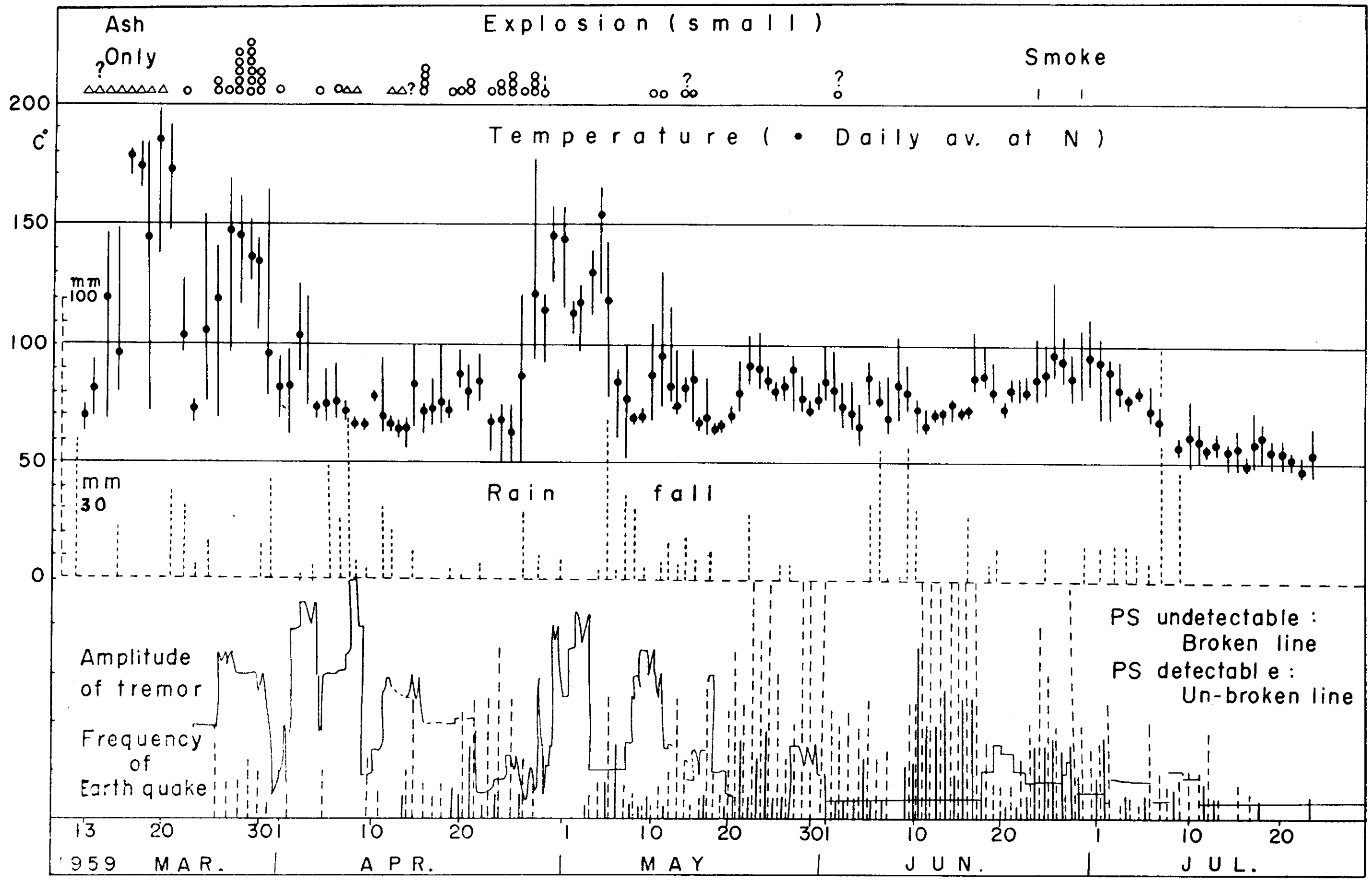

Fig. 11. Variation of the temperature, tremor (earthquake) and surface action of the Naka-dǻke crater, and rain fall at the Aso L.M.O. The data of tremor (earthquake) were given by Shimozuru, D. and his collaborators, and rain fall was measured at the Aso L.M.O.

under the ground surface, and connected by electric lines with the indicators which were set at the Aso Museum, approximately 1000 m distant from the crater (Fig. 2).

Before constructing the apparatus, the relationship between temperature and registivity of the thermistor was inspected in the laboratory, and then, a suitable indicator was designed, which was composed of the bridge circuit with 3 range select (0–100°C, 100–200°C and 200–300°C). The error due to the registivity of the lead wire between the thermistor and the indicator (about 1000 m length) was compensated. Dry cell (3V) as a source of electricity, and ammeter (full scale 50 μA, maximum measurement error 2%) were used.

At a new eruptive hole opened at the bottom of the 1st crater on the 25th of September, activity increased till it began to eject essential ejecta on the 20th of October in 1958. The measurement was successfully conducted throughout the period of eruptions, though it was suspended during winter, because the electric line was frozen and broken.

The 2nd measurement period opened at the S point on the 13th of May, 1959, was continued until the 23th of July. Small explosions occasionally happened during this period also.

The temperature measurement was conducted at every 30 minutes. For example the results obtained during 8 days, Sep. 23–26 and Oct. 13–16, 1958 are shown in Fig. 3. It is to be noticed that the variation trends at the two measurement points, N and S, are similar to each other. This is verified by Figs. 4–9, in which the average temperatures for a six hour period and the daily average temperatures are shown along with the rain fall.

Table 1. Relation between the daily average temperatures of crater and rain fall (after the Aso L.M.O.)

	Number of rainy days Period I	Period II
1. Temperature increased continuously throughout the days before and after a rainy day	14	15
2. Temperature began to rise on the day after the rain fall	7	11
3. Temperature decreased continuously throughout the days before and after a rainy day	9	15
4. Temperature began to decrease on the day after the rain fall	11	14

Period I: 121 days (Aug. 28—Dec. 26, 1958)
Period II: 133 days (Mar. 13—Jul. 23, 1959)

The relation between the average temperatures and the activity of the crater and rain fall are listed in Tables 1–4. At a glance at Figs. 4–9 and Tables 1–4, we can point out several notable facts as follows:

Table 2. Relation between the daily average temperatures and explosions

Period I August 28—December 26, 1958

	Number of explosions N	S	
1. Two days before a temperature peak	10*	10*	pre-Peak
2. The day before a temp. peak	10*	11*	pre-Peak
3. The day showing a temp. peak	13	12	
4. The day after a temp. peak	*13*	*16*	post-Peak
5. Two days after a temp. peak	13	15	post-Peak

Period II March 13—July 23, 1959

	Number of explosions N	
1. Two days before a temperature peak	10*	pre-Peak
2. The day before a temp. peak	13*	pre-Peak
3. The day showing a temp. peak	11	
4. The day after a temp. peak	*15*	post-Peak
5. Two days after a temp. peak	10	post-Peak

* Most of the pre-Peak explosions (1 & 2) which took place before the temperature peaks are the same as the explosions which were numbered as the post-Peak explosion (4 & 5), because the peaks of temperature variation are usually about two days apart.

The daily observation of the crater was mainly done by the Aso L.M.O. and by the "Co-operative Observation Post" of the Kyushu University and the town of Aso.

1. The temperature change of the Naka-dâke crater seems not to be related to the rain fall.

2. The explosion or increased activity took place usually at the temperature peak period, the "post-peak explosions" rather predominating, that is to say, in most cases, the explosion or increased activity occurred: (1) within about 12 hours following the peak of the average temperatures for a six hour period, or (2) on the day after the peak of daily average temperatures.

3. The temperature variation was larger during the period of comparatively higher temperature than during the period of lower temperature.

4. So far as the data obtained is concerned, it is concluded that the beginning of distinctive increase in temperature variation and average temperature indicates the possibility of explosion within two or three days.

Table 3. Relation of the average temperatures for a six hour interval to the explosions during 58 days, March 23–May 19, 1959

		Number of temperature peaks	Number of explosions	
1	Explosion occurred within 24 hours prior to a temperature peak	11*	43*	pre-Peak
2	Explosion occurred within 12 hours prior to a temperature peak	11*	19*	
3	Explosion occurred within 6 hours prior to a temperature peak	7*	7*	
4	Explosion occurred during a temperature peak period	6	6	
5	Explosion occurred within 6 hours following a temperature peak	*12*	*12*	post-Peak
6	Explosion occurred within 12 hours following a temperature peak	*14*	*24*	
7	Explosion occurred within 24 hours following a temperature peak	17	44	
	Total number of peaks 39,	Total number of explosions 45		

* Most of the peaks accompanied with a pre-Peak explosion (1, 2 & 3) are numbered as the peak with a post-Peak explosion (5, 6 & 7) at the same time, because most of the temperature peaks are about 24 hours (usually less than 40 hours) apart (ref. Table 4). In the same manner most of the pre-Peak explosions are treated as the post-Peak explosions at the same time. Therefore it is more reliable that the post-Peak explosion, especially within 6 or 12 hours following a temperature peak, predominates in number.

Table 4. Number of peaks accompanied with a pre-Peak explosion during 58 days, March 23—May 19, 1959

Explosion occurred within 12 hours prior to a temperature peak	11	Explosion occurred within 12 hours following a temperature peak	8
		Explosion occurred during a temperature peak period	1
		No explosion occurred within 12 hours following a temperature peak	2
Explosion occurred within 6 hours prior to a temperature peak	7	Explosion occurred within 6 hours following a temperature peak	7
		Explosion occurred during a temperature peak period	0
		No explosion occurred within 6 hours following a temperature peak	0

5. Regular relation was not found between the explosions and the tremors or earthquakes, it is, however, possible to presume that (1) the distinctly frequent

variation of amplitude of the tremors or earthquakes appears to take place during the period of temperature peak, and that (2) in appearance the peak of amplitude seems retard (several days?) from the temperature peak (Figs. 10 & 11; refer to Fig. 5 (TANEDA, 1962)).

The daily observation of the crater was mainly done by the Aso L.M.O. and by the "Co-operative Observation Post" of the Kyushu University and the town of Aso. The data for tremor and earthquake was also treated by courtesy of the Aso L.M.O. and Assistant Prof. D. SHIMOZURU of this Faculty.

As to the source of volcanic energy, short description of the Naka-dâke ejecta are given below.

At Aso Volcano has never flowed out lava from its crater, but at sometimes has ejected essential-accessary materials in the historic times. All of the essential ejecta were of basic pyroxene andesite (SiO_2 52–54%). The bombs and scoria block-fragments ejected by the 1958 (October) eruption were also olivine-bearing hypersthene-augite andesite (SiO_2 about 53%).

The chemical compositions are listed in Table 5, and the ratios Total FeO: MgO: Alkalies in the products of the Aso eruption are shown in Fig. 12.

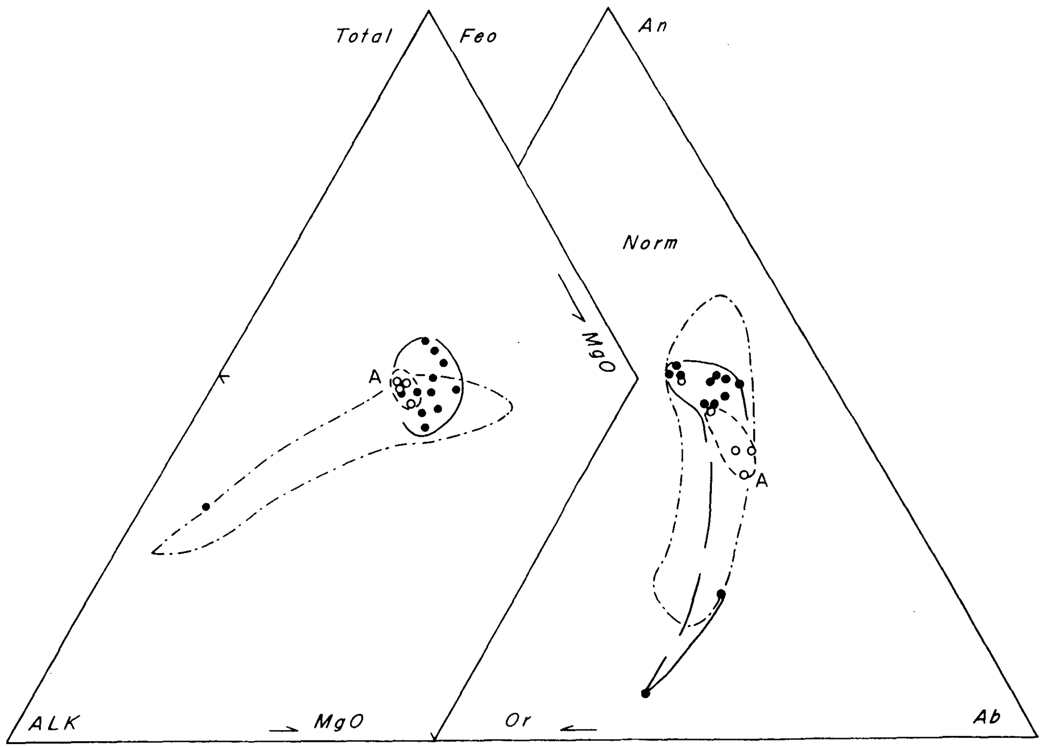

Fig. 12. The products from the Aso volcano. Open circles: bombs and scoriae of historic times. A: scoriae of the 1958 (Oct.) eruption. Solid circles: lavas of prehistoric times. Chain lines show the area, in which are plotted most of the welded tuffs of the somma.

Table 5. Chemical compositions of the essential ejecta of the 1933 and 1958 (October) eruptions

	1	2	Remarks
SiO_2	53.21	52.66	
TiO_2	0.48	0.95	
Al_2O_3	17.39	18.31	1. Essential ejecta of the 1958 (October 27) eruption
Fe_2O_3	3.83	3.24	(Taneda, 1962).
FeO	6.48	5.89	Olivine-bearing hypersthene-augite andesite
MnO	0.10	0.13	(scoriaceous).
MgO	4.22	4.40	Collected by Taneda and analysed by J. Morita
CaO	9.35	8.67	
Na_2O	3.77	3.73	2. Essential ejecta of the 1933 eruption (Kawano,
K_2O	1.90	1.89	1934).
H_2O+	0.58	0.26	Olivine two-pyroxene andesite.
H_2O-	0.10	0.29	
P_2O_5	0.32	0.28	
Total	101.73	100.70	

Acknowledgements

I am much indebted to Messrs. M. KOZIMA, H. MATUO and N. KUNIYOSHI, all formerly of this institute, for their courageous help for this investigation, and Assistant Professor D. SHIMOZURU for his advice on measurement. The Aso Local Meterological Observatory (L.M.O.) and the Town Office of Aso-mati gave facilities for this research. Messrs. Haise and TAKEHARA conducted temperature reading at the Aso Museum. Professor T. TOMITA read this manuscript with kind criticism. I wish to express my cordial thanks to these authorities and gentlemen.

P. S.

It appears to be important to promote the measurement works as well as the data analyses in detail in the future. It would be desirable to have an opportunity to obtain data, useful as an indicator in finding the rising of the distinct eruption following a dormant stage.

Reference

KAWANO, Y. (1934): The 1932–33 eruption of Volcano Aso, Japan. *Jour. Jap. Assoc. Min. Petr. Econ. Geol.*, **11**, 208–216 & 12, 15–26 (in Japanese).

TANEDA, S. & MATSUMOTO, Y. (1954): The 1953 eruption of Volcano Aso, Kyushu, Japan. *Jour. Geol. Soc. Japan*, **60**, (702), 106–112 (in Japanese).

TANADA S., MATSUMOTO, Y., MIYACHI, S., MIYACHI, M., ISHIBASHI, K. & KOZIMA, M. (1957): The 1958 June eruption of Volcano, Aso. *Bull. Volc. Soc. Jàpan*, II, **3**, (2), 136–146 (in Japanese).

TANEDA, S. (1962): Temperature variation of active crater. *Jour. Jap. Assoc. Min. Petr. Econ. Geol.*, **47**, 57–64.