22. *On the Recent Explosive Eruptions of Volcano Sakura-jima, Southern Kyushu, Japan.** (I)

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Introduction

Volcano Sakura-jima, one of the most frequently active volcanoes in Japan and world-famous for its big eruption of 1914, became explosively active with a sudden explosion on Oct. 13, 1955, at about 14 h 56 m. After more than fifteen explosive eruptions, the volcano once more recovered its ordinary state of fumarolic activity at the end of the month, only continuing to emit white vapors for the rest of the year. But since Jan. 6, 1956, when the volcano resumed eruptive activity, it has been in a continual state of explosive eruption with more than fifty eruptions during the five months until now (about the end of May, 1956) when its activity is still going on with intermittent explosions.

The writer visited the volcano in August, 1955, and observed the actual state of its crater region within two months before the beginning of the present eruptions. In Dec., 1955, T. Watanabe, an assistant to the writer in the Institute, made a field investigation of the Oct. (1955) eruptions and collected a number of rock specimens ejected by the eruptions. On visiting the volcano again in April, 1956, the writer had an opportunity to see the actual scene of the explosive activity then in progress, and discovered new lava blocks and bread-crust bombs among the recent ejecta scattered about the ground within a radius of about 1000 m of active crater.

As things now are, the present activity of Sakura-jima is nothing more than a repetition of explosions of minor intensity and short duration. But this activity is remarkable in that it is taking place in the

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(1) Recent Eruption of Volcano Sakura-jima. (Read Nov. 22, 1955)

(2) Recent Ejecta from Volcano Sakura-jima. (Read Mar. 27, 1956)

(3) Recent Eruption of Volcano Sakura-jima and Its New Ejecta. (Read May 22, 1956)

summit crater of the volcano, and has lasted for more than five months. As a matter of fact it is an unusually long eruptive activity, never before recorded in the history of the eruption of the crater. At present it is too early to make any predictions about the future progress of the activity, although a hopeful view is that, after keeping its present state for some time, the activity will gradually die down to the ordinary fumarolic activity, without culminating in any disasterous eruptions like those of 1914 and 1946.

This paper is a preliminary report on the recent eruptions now still in progress, including the results of field observations and studies of the ejecta collected by the writer and T. Watanabe. We take this opportunity to express our great appreciation of the valuable assistance and many courtesies rendered us by the local authorities with whom we came in contact, among whom must be specially mentioned: Messrs. K. Otsuji and I. Muraoka, members of the staff of the prefectural office at Kagoshima; Mr. S. Dake, Master of Nishi Sakura-jima (village); Mr. N. Imasato, Director of the Local Meteorological Observatory at Kagoshima, and Mr. Y. Yasui, Chief of the Observation Section of the Observatory.

Volcanic activity prior to the present eruptions

The volcano of Sakura-jima is situated directly opposite the city of Kagoshima, in the northern part of Kagoshima Bay—a drowned volcanic depression called Aira Caldera[1]. When viewed from a distance, the volcano looks like a simple truncated cone (Fig. 6), but in reality its upper part consists of three volcanic peaks, Kita-daké (North Peak), Minami-daké (South Peak) and Naka-daké (Middle Peak), each having its own crater at the top. These peaks have been formed in juxtaposition in the order mentioned, as can be seen from the structural relation of their ejecta indicating that the southern slope of Kita-daké is largely covered by the main part of Minami-daké and the northern side of the top of Minami-daké by the mass of Naka-daké (Fig. 7).

Kita-daké, the oldest of the three peaks mentioned, occupies the northern half of the volcano of Sakura-jima, rising 1,118 m high above sea-level (Fig. 8). Its summit crater is circular, about 450 m in diameter, the eastern rim rather flat and low, while to the north, west,

1) T. MATSUMOTO, "Volcano Aira," *Chirigaku Hyoron (Geographical Review)*, **9**, (1933), 614 (in Japanese).

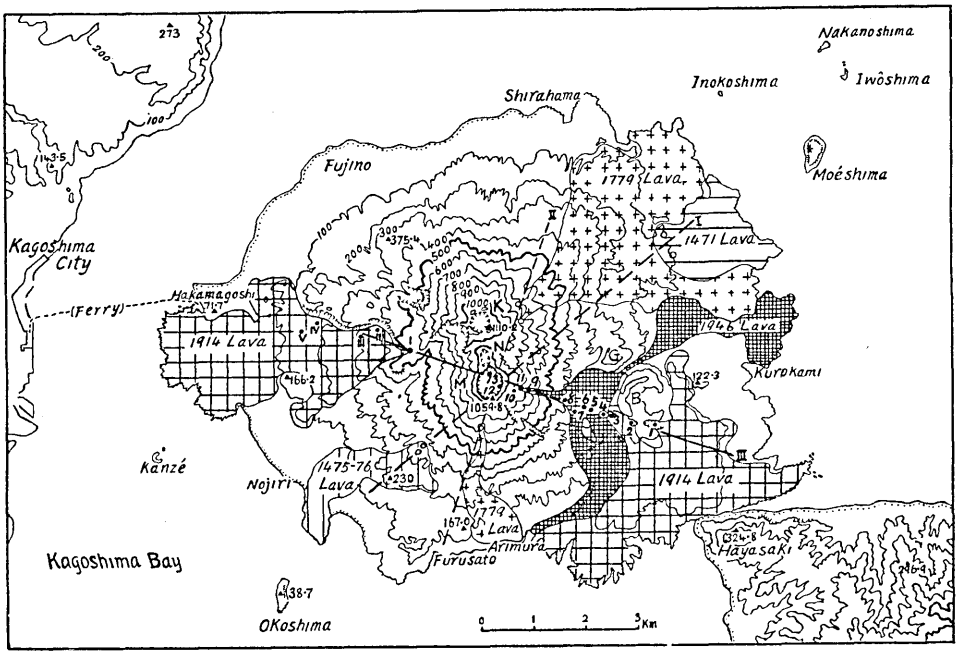

Fig. 1. Map of the volcano Sakura-jima. K, Kita-daké; N, Naka-dake; M, Minami-daké. Radial lines I, II, and III indicate lines of vents (craters) of 1471, 1779, and 1914–1956 respectively. Numbers 1–8 and 1–V, vent of 1914; 9, vent of 1939; 10, vent of 1948(?); 11, vent of 1946; 12, vent of 1950; 13, vent of 1955–56.

and south the rim is capped for the most part with a thick sheet of lava, forming a narrow, rugged ridge cut by the precipitous crater-wall within. The bottom of the crater, about 70 m in depth below the highest point of the rim, is nearly flat and is covered with pumice and other fragmentary ejecta mostly of the lapilli grade. At the foot of the southeast wall is a long, narrow crescentic valley which, separated from the main part of the crater-floor by a low ridge, represents the remnant of an older, outer crater. The volcanic activity of Kita-daké must have already long since become extinct. Thus, no sign of fumarolic or solfataric activity is visible in the summit crater or elsewhere on the outer slopes of the peak; neither eruption nor vapor emission from the Kita-daké crater has been mentioned in the historic record of activity of the Sakura-jima volcano[2]; and the north and west slopes of

2) An eruption accompanying lava outflows occurred in 1779 halfway down the eastern slope of Kita-daké, and another in 1471 at the northeastern foot of the same mountain. These eruptions were not of the Kita-daké volcano, but were caused by the activity of the Minami-daké volcano, each representing one of its bilateral eruptions. See Fig. 1.

the peak have been cut by deep, radial valleys, the slopes on the other sides are rather smooth, being covered by ejecta from the adjoining younger volcanoes Naka-daké and Minami-daké.

Naka-daké, adjoining the southern slope of Kita-daké, rises 1070 m high above sea-level, but only about 70 m above the saddle lying between the opposite slopes of the two peaks (Fig. 8). When viewed from the southern rim of the Kita-daké crater, it looks like an independent cone, but in reality it is combined on its south side with the Minami-daké cone. Thus, the summit crater of Naka-daké, which is oblong in form, about 300 m in its longer N.-S. diameter, and less than 20 m in depth, is situated immediately on the outside of the north rim of the summit crater of Minami-daké. The floor of the crater is but slightly hollowed toward the centre like a shallow dish, covered with ash and pumice, and is strewn with many angular blocks of lava. The crater rim, except for small portions on the southwest and southeast, where lava crags stand high, forms a nearly flat ground ending outward at the steep outer slopes; the south rim in particular ends abruptly at the top of the precipitous, north wall of the Minami-daké crater, affording a place from which one of the best views of the interior of the latter can be obtained.

Neither eruption nor fumarolic activity of the Naka-daké crater has been mentioned in the record of activity in historic times of the Sakura-jima volcano; at present the crater appears to have become extinct without leaving any trace of fumarolic activity on its floor. But, as already mentioned, the Naka-daké cone adjoins to and rests on the northern side of the summit of the Minami-daké cone which is active at present. Moreover, so far as examined microscopically, the lavas ejected from the Naka-daké crater are similar to those which form the wall of the summit crater of Minami-daké. Therefore, as a matter of course, Naka-daké may be regarded as a short-lived, parasitic volcano representing subterminal, lateral eruptions of the Minami-daké volcano.

Minami-daké rises 1060 m high above sea-level, occupying the southern half of the Sakura-jima volcano. Its outer slopes, except for the northern side where the two other peaks (Naka-daké and Kita-daké) stand as noted above, present a conical surface with a slope varying from about 30° near the top to less than 10° at the base. On the slopes, there are a number of parasitic craters, most of which are arranged on several lines drawn radially through the summit crater of the main cone and suggesting eruptive fissures in the cone.

The summit crater of Minami-daké is nearly oval in form, about 600 m long from north to south, 500 m wide from west to east, and has a depth of a little over 100 m (Fig. 2). The crater rim, for the most part, is a sharp edge formed by the steep outer slope of the cone and the precipitous wall within, and presents a ragged crest-line serrated with many lava crags and breaks, so that it is almost impracticable to walk entirely around it. The inner walls are nearly vertical in the upper part and tend in the lower part to a talus slope of lava blocks fallen from the walls above. The bottom of the crater is circular in form, about 300 m in diameter, and is covered with ash[3] (Figs. 9, 10).

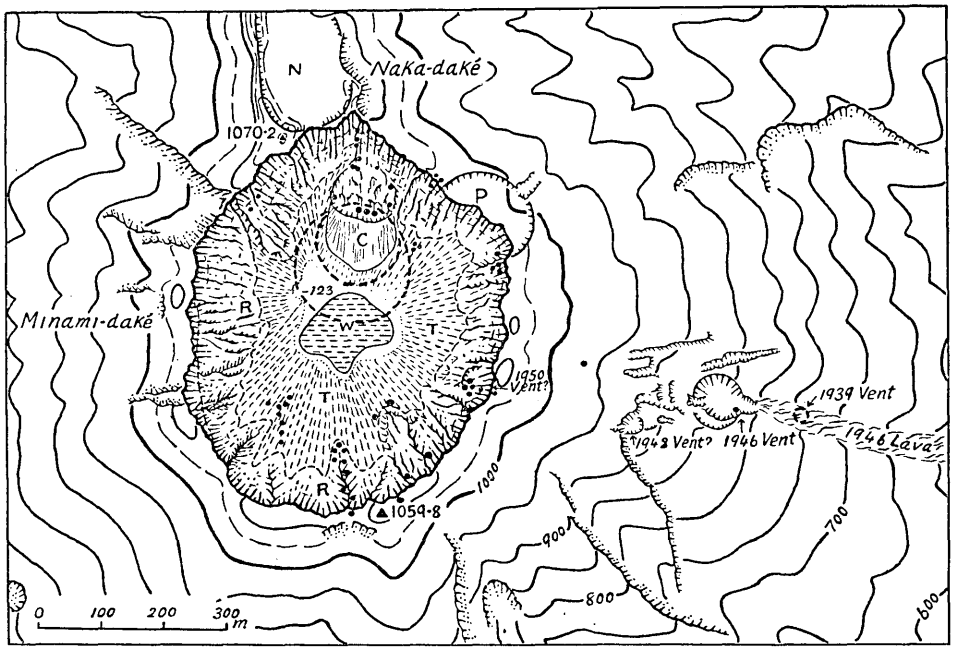

Fig. 2. Map of the summit of Minami-daké, showing the state of its crater, as of Aug. 17, 1955. N, Naka-daké crater; P, ruin of an old crater; R, rocky cliffs of the inside walls of Minami-daké crater. T, talus; W, temporary pool of water at the bottom of the crater; C, apron-like talus. Black dots indicate fumaroles. Chain circles indicate rims of the crateral depressions formed by the explosions of October, 1955. Cf. Fig. 5.

3) A descent into the crater can be made by taking advantage of the acquired relative gentleness and stability of the slope of its southwest wall, being started at a low point on the rim.

The crater has been active in historic times, being the scene of the eruption now going on with repeated explosions. Its normal condition is a fumarolic activity giving off moderate amounts of vapors, enough to form a transient cloud above the crater. Thus fumaroles are very active and numerous, mostly occurring over the inner north and east walls of the crater. The bottom of the crater is usually devoid of active fumaroles except in its northern part, near the base of the north wall, where several occur at present in and about the new inner crater formed by the present eruptions.

History records a number of eruptions of the Sakura-jima volcano, those prior to 1914 recorded as having occurred in 708 A.D., 716–718, 1468, 1471, 1473, 1475, 1476, 1478, 1642, 1678, 1706, 1742, 1749, 1756(?), 1766(?), 1779–1783, 1785, 1790–1792, 1794, 1797, 1799, and 1860. This chronological list shows that, before the present century, the volcano had at least three distinctive periods of eruptive activity. Of these, the activity of the first period in the early eighth century is only recorded briefly as eruptions of Mukai-jima (the old name for Sakura-jima), while the activity of the second period in the late fifteenth century (1468–78, the era of Bummei) and that of the third period in the late eighteenth century (1779–99, the era of An-ei) are big ones known as the Bummei and An-ei eruptions respectively, each being unique bilateral eruptions that occurred on the northeast and southwest flanks of the volcano, either simultaneously or in succession, with lava outflows and ash explosions. These eruptions are separated from each other with long periods of no recorded activity, although a few eruptions, probably of a small scale, are recorded as having occurred at intervals within one and a half century before the An-ei eruptions. The record of activity of the volcano in a little more than a century after the An-ei eruptions is also scanty, showing that this period is virtually of relative quiescence, coming to an end with the outbreak of the big 1914 eruptions. So far as the historic records now available are concerned, violent eruptions of a magnitude comparable with the 1914 eruptions seem to be rather infrequent, having taken place at intervals of more than a century. But the interval of seven centuries between the eruptions of the first (716–718) and second (1468–78) periods may be too long as a period of continuous repose for an active andesitic volcano like Sakura-jima, and there is no apparent reason for denying the possibility of occurrence of some eruptions in that long period.

The 1914 eruptions, which have been described in detail by B.

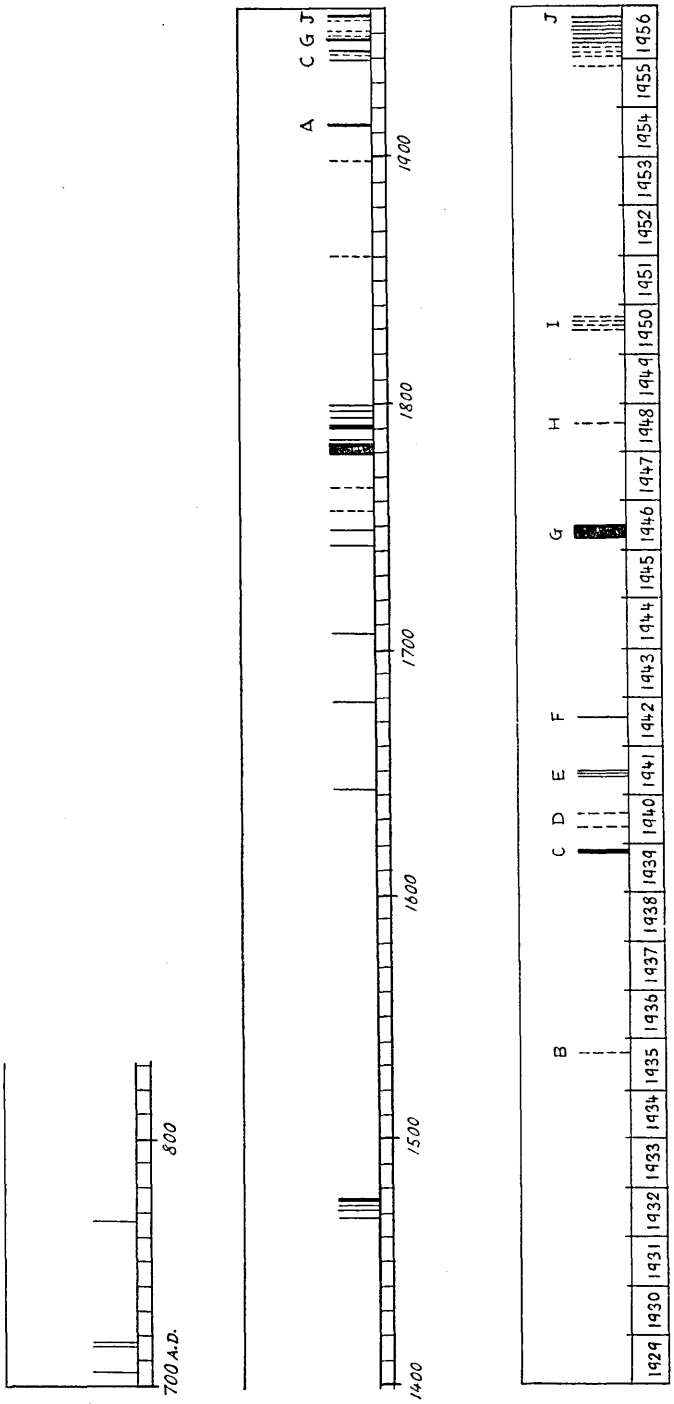

Fig. 3. Diagram showing the frequency of eruptions of Sakura-jima in historic times. Chain lines indicate volcanic explosions of superficial nature.

Koto[4], F. Omori[5], and many others, are ranked among the great eruptions that have occurred in the world in historic times, being more or less greater in magnitude, though of shorter duration, than the Bummei and An-ei eruptions. It is remarkable that, as in both of these, the mode of activity in 1914 was also a bilateral eruption. Thus this eruption took place with many precursory earthquakes (about 417 in the preceeding thirty hours) in Jan. 12, 1914 (the third year of the Taisho era), when a series of bocche was formed on the west and east slopes of Minami-daké, along a WNW.-ESE. line suggestive of a radial fissure running in this direction through the summit crater of the mountain (Fig. 1). These bocche developed soon into craters, large and small, vying with each other in displaying violent explosions and lava outflows.

Since the Taisho eruptions of Sakura-jima in 1914, the volcano had been quiescent and generally in a state of fumarolic activity, no outflows of lava or definite explosions having been reported, until 1935 when a small ash explosion occurred in Sept. at the summit crater of Minami-daké. Since then, the volcano has become more active with eruptions in 1939 (Oct.), 1940 (July), 1941 (April–June), 1942 (July), 1946 (March–June), 1948 (July), 1950 (June–Sept.), 1955 (Oct.) and 1956 (Jan.–)[6]. Of these, the 1939 and 1946 eruptions, together with the recent (1955–56) eruptions to be mentioned later, were more violent than the rest, although none of them surpassed the 1914 eruptions. It is remarkable that all the eruptions since 1935 have taken place from vents lying on or very close to the line of craters of 1914, and that no material change has occurred in the petrographic character of the lavas ejected by the eruptions since 1914. Therefore, these eruptions may be regarded as belonging to one and the same period of activity—the fourth period of activity of the volcano in historic times, although after the 1914 eruptions some twenty years elapsed before the volcano gave any decided evidence of entering on a period of renewed activity.

The 1939 eruption occurred at a newly-opened vent on the east flank of Minami-daké, about 750 m above sea-level, and on the line of craters of 1914. It was a minor explosive eruption of short duration,

4) B. KOTO, "The Great Eruption of Sakura-jima in 1914." *Jour. Coll. Sc., Imp. Univ.*, Tokyo, **38** (1916), 221–237.

5) F. OMORI, "The Sakura-jima Eruptions and Earthquakes," *Bull. Imp. Earthq. Inv. Com.*, **8** (1914–19), Nos. 1-6.

6) As to the monthly activity of the volcano, information can be obtained from the Kisho Yoran (Geophysical Review), a monthly journal published by the Central Meteorological Observatory (C. M. O.).

but was unusual and worthy of notice in having caused a typical hot avalanche (nuée ardente), the occurrence of which was witnessed and pictured by a casual observer for the first time in Japan[7]. With a convulsive explosion, a chaotic mass of hot lava-blocks, bread-crust bombs, pumice and other rock-fragments was ejected from the new vent, and together with a rolling ash-laden vapor cloud, descended the steep slope of the mountain eastwards for a distance of about 700 m, forming a downward train of glowing cloud which reminded us of the type of eruption-cloud observed in 1902 by A. Lacroix and in 1930 by F. A. Perret at Pelée on the Island of Martinique.

A small explosive activity occurred at the summit crater twice in June and once in July, 1940; the activity each time came immediately after a heavy rain-fall, causing ejection of black ash-cloud up to a height of several hundred meters above the rim of the crater, but no visible incandescent matter. By the activity, a new explosion vent was opened in the east wall of the crater, being located near, if not exactly on, the extension of the line of craters of 1914 and in a section of the crater wall where, in Dec., 1939, a considerable vapor was seen issuing from several fumaroles, accompanied by hissing noises.

In April-June, 1941, there took place an explosive activity at the 1939 crater or thereabout, on the east flank of the volcano. This activity was by far larger in magnitude and longer in duration than the foregoing. Thus the first explosion took place on April 28, at about 21 h 10 m, was heard in the city of Kagoshima, where it caused doors to rattle, and brought about a little ash-fall; incandescent matter was seen flying through the evening air above the crater; and a forest fire broke out caused by the heat of the falling ejecta on the flank of the mountain, lasting for about an hour. This explosion was followed by the emission of a considerable vapor-cloud for three days ending May 1, and this latter was succeeded by a period of relative quiescence in the first half of May. The activity was revived on May 15, with an explosion accompanying a column of black ash-cloud, about 600 m high. From this day through the first half of June, the activity continued with recurrent explosions, sometimes in company with shocks recorded at the Kagoshima Meteorological Observatory, and was culminated during five days, May 29-June 2, by the appearance of a fire column a few hundred meters high above the crater, together with the ejection of

7) H. TSUYA and T. MINAKAMI, "Minor Activity of Volcano Sakura-jima." *Bull. Earthq. Res. Inst.*, **18** (1940), 318-338 (in Japanese).

red-hot cinders for a distance of several hundred meters.

A single explosion, accompanied by cinder-and ash-fall, occurred on July 16, 1942, this time again at the 1939 crater or thereabout on the east flank of the volcano[8].

In the first half of 1946, the volcano staged a spectacular eruption, the largest that had occurred for years[9]. It had already become explosive at the beginning of that year, intermittently sending up puffs of ash-cloud to a height of several hundred meters, and it remained in an explosive condition until March 9, when lava began to issue from a new vent on the east flank of Minami-daké. The forerunning explosive activity must have taken place to effect a resurgence of lava-eruption at the new vent. The lava-eruption continued for about three months ending toward the beginning of June; effusion of incandescent lava and explosive ejection of its fragments (bombs and cinders) were taking place alternately and almost in succession; the lava flowed almost due east for a distance of about 1 km, then divided itself into two flows, one reaching the east coast in the village of Kurokami and the other the south coast in the village of Arimura. The total volume of the new lava was estimated to be approximately 10^8 m^3, which put the eruption in the grade VI of the writer's intensity scale of volcanic activity[10], about one tenth of the intensity of the 1914 eruption. Considerable damage was done to forests, farms and houses in the lava-stricken villages of Kurokami and Arimura.

The 1946 eruption was not a revival of activity of the 1939 vent, but occurred northwest of and some 150 m apart from the latter, on the extension of the line of craters of 1914, showing the centre of eruptive activity of the volcano as having moved stepwise along this line from the east foot towards the summit crater.

On July 27, 1948, a short, explosive eruption took place on the east flank, at the top of a horseshoe-shaped lava-cliff, northwest of and close to the 1946 vent[11]; loud detonations were heard at Arimura and ash fell in Kurokami; ejection of dark ash-clouds, up to a height of about 1200 m, continued until the end of the month.

8) *The Quarterly Journal of Seismology (Kenshin Jiho)*, C. M. O., 13 (1944), 323 (in Japanese).

9) T. HAGIWARA et al., "The Eruption of Mt. Sakura-jima in 1946." *Bull. Earthq. Res. Inst.*, **24** (1946), 143-160 (in Japanese).

10) H. TSUYA, "Geological and Petrological Studies of Volcano Fuji, V." *Bull. Earthq. Res. Inst.*, **33** (1955), 341-382.

11) *The Quarterly Journal of Seismology (Kenshin Jiho)*, C. M. O., **15** (1951), 49 (in Japanese).

An explosive eruption began on June 29, 1950, in the northeast section of the inside wall of the summit crater, and continued with intermittent explosions until the end of September, the same year. Thus, ash fell on the foot of the volcano on June 29 and 30, July 4, 5, 19, 22, 24 and 25, Aug. 8, 9, 10 and 31, Sept. 3, 5 and 9, and in the city of Kagoshima on July 25 and Aug. 8; on Sept. 3, at night lightning accompanied by detonations were observed, in the direction of the volcano at the Kagoshima Meteorological Observatory. The centre of eruptive activity of the volcano, which had been moving upward along the line of craters of 1914 on its east flank, must have approached the summit crater by the time of the 1950 activity. The recent activity has been taking place again in the summit crater since last October.

The state of activity and other conditions of the volcano as observed in Aug., 1955

The summit crater of Minami-dake. Since the explosive activity of 1950, the volcano had been in a fumarolic state, no definite explosions having taken place. In Aug., 1955, when the writer visited the volcano, with T. Watanabe, the bottom of the summit crater was in a state of closed conduit, as it had been for a long time, without showing any sign of fumarolic activity; its floor was nearly flat, covered with ash, and was occupied for the most part with a pool of water, seemingly less than 1 m in depth (Fig. 2). The pool appeared to be muddy for the most part, but was yellow to fawn-colored near the shore, probably receiving its color from some precipitates containing sulphur and iron oxide (Figs. 11, 12).

Inside the summit crater fumaroles were in activity in all parts of the walls excepting the southwest, showing features related to two distinct types—fumaroles proper and diffuse exhalations. Some were also in action on the upper part of the outer slope, these being confined to the east and southeast sections.

The fumaroles proper were very active and numerous in the north and east walls of the crater, consisting in powerful, hissing jets of whitish vapors from holes or crevices at more or less fixed spots in the walls. The largest, most prominent, and most active fumarole was half way up the east inner wall, giving off continuously a great deal of white vapor which issued with considerable violence and a loud hissing noise. The vapor-clouds issuing from the fumarole were so thick and large that, on looking down from the crater rim above, we were award-

ed a view of the interior of the crater only at times when the air above the fumarole became momentarily cleared of the clouds by the transient wind. A bright yellowish deposit was seen accumulating all over the ground around the fumarole (B in Figs. 15, 16).

The above-mentioned fumarole was not only large, consisting of more than one orifice, but was accompanied by a number of smaller and less active fumaroles, all forming a group, "B" group, as it has been named by the Kagoshima Meteorological Observatory. The site of this group was almost free of fumaroles in 1939, when the writer visited the volcano soon after the October eruption. An air photograph of the summit crater, taken by the Asahi (news agency) in March, 1946, when the afore-mentioned lava-eruption was in progress on the east flank of the volcano, presents a clear view of the site in question without being obscured by any thin film of vapors rising from fumaroles (Fig. 9). Moreover, as shown in the photograph, the site in question was an almost perpendicular cliff in 1946, extending from the crater-rim above to near the crater-floor, while in 1953 and 1955 it was found to be a crater-like hollow, full of fumarolic activity, in the middle of the cliff (Figs. 15, 16). Therefore, the fumarolic activity at this place may be regarded for the most part as having started or become remarkable in particular some time after 1946, probably at the time when the said hollow was formed. It is probable that the explosive activity of the volcano in 1950 took place at this place, causing the fumarolic activity as one of its after-effects.

In the lower part of the north wall of the summit crater was a ditch-like hollow, the length of which was judged to be about 100 m from east to west, with a width of about 30 m. The north side of this hollow was the precipitous cliff of the crater-wall, while its south side was surrounded by a bank of detritus, the outer slope of which was a talus-like declivity, covered with a dark muddy material, and sloping at about 30° toward the centre of the crater-floor. It looked as if a giant apron, to use a figure, was set against a vertical wall. The surface of the slope was almost smooth, showing its recent birth, although it was seen to have been cut by a number of small, parallel gullies (Figs. 11, 12).

White vapor-clouds were slowly welling up from within the above-mentioned hollow in the north crater-wall. Besides, there was a constant emission of thin, bluish fume rising very slowly. The forms of the puffs of these vapor and fume suggested the presence of more than one fumarole below, but none of their orifices were recognizable as not

even a glimpse of the bottom of the vapor-filled hollow above was to be had. The fumaroles in and about the hollow have together been named "A" group by the Kagoshima Meteorological Observatory.

In the north crater-wall, there were few or no fumaroles in 1939, when there was a talus slope covering its lower part (Fig. 10). Almost the same condition appears to have been prevailing in the wall in 1946, as shown in Fig. 9. Therefore, the fumarolic activity in the wall in recent years must have started or become noticeable at some time after 1946. A photograph of the crater, taken in 1953, shows its north wall attended with several fumaroles giving off small masses of white vapor-clouds; in the lower part of the wall and slightly below a group of small fumaroles is seen a talus slope, the surface of which is cut by small gullies running down towards the crater-floor; but the picture is unsatisfactory for ascertaining whether the talus slope is cut at its head by an opening like the smoking hollow mentioned above (Fig. 15). In either case, this hollow must have been formed within a few years before 1955, probably by an erosive action of vapors issuing from the fumaroles which found their outlets at the head of the talus slope, even if the vapor emission never attained an explosive violence. The bluish fume which was seen issuing from within the hollow in 1955 suggests that the fumaroles at its source were higher in temperature than those giving off white vapors, as is often the case with other volcanoes. Thus while the fumaroles ("B" group) in the east crater-wall were most prominent in emitting white vapors, those ("A" group) in the hollow were regarded as being thermally most active, and it was presumed that the site of the hollow would be the centre of eruptive activity if this activity should occur within the summit crater in the near future. The recent eruptive activity, which began in Oct. last year, has been occurring at this place, as was expected, blowing off the talus-slope in the lower part of the north crater-wall and boring a new explosion crater in its place, to be mentioned later.

There were several fumaroles in the upper part of north crater-wall, immediately above the smoking hollow mentioned. Of these, three were more active than the rest, setting up slender columns of a dense, white vapor. Near the upper edge of the northwest wall was seen a group of small fumaroles emitting vapors constantly but very faintly.

A small amount of white vapor was rising from the lower part of the northeast crater-wall, immediately to the southeast of the fumarole group "A", issuing from fumaroles at a few, more or less fixed spots.

In 1939, this place was the scene of the most active fumaroles in the summit crater, showing a constant emission of a great deal of white vapor from a number of cracks in the lava crag exposed there; it was in the middle of a shallow basin which, in appearance, did not suggest an explosive origin, but seemed to have been formed largely by the fumarolic activity—an erosive action, both mechanical and chemical, of the vapors that could open a way through the superincumbent talus. The same group of fumaroles appears to have still remained the most active in 1946, as shown in Fig. 9; it appears to have become a little less active in 1953, as shown in Fig. 15; while in 1955 only a few fumaroles were left alive as a vestige of the group, emitting vapors but thinly, as mentioned above. It is plausible that this fumarole group was getting less active as the neighbouring groups "A" and "B" became more active in recent years.

In the south crater-wall, there were two prominent groups of fumaroles, each emitting white vapors from cracks in the lava exposed on the wall. They were seemingly inactive in 1939, without coming the writer's notice on the scene; one of them was a little active in 1946; and this, together with the other, was still more active in 1953, showing almost the same condition as they were in 1955.

Besides the fumaroles mentioned thus far, smaller and isolated fumaroles were present in various parts of the crater-walls. Some were also in action on the upper part of the outer slope, these being confined to the east and southeast sections. On the east slope near the rim of the summit crater, there were also the so-called diffuse exhalations consisting of a gentle, quiet, and noiseless emanation of hot vapors, which appeared to be mostly steam, through crevices and the less coherent bed of pumice. One of the small fumaroles on the slope showed the temperature of 78°C at its orifice, while the atmospheric temperature was about 25°C.

In short, it may be said that the fumarolic activity of the summit crater as observed in Aug., 1955, was larger than that in the preceding several years during which an increase of the activity had been taking place, as shown by a decided increase in the number and distribution of the fumaroles in the crater. The emission of bluish fume, which in Aug., 1955, was seen taking place from the smoking hollow in the lower part of the north crater-wall, may be regarded as having told the beginning of a reawakening of eruptive activity at the crater. Thus the recent eruptive activity began on Oct. 13, resulting in the

formation, at the site of the previous smoking hollow, of an explosion crater, to be mentioned later.

The 1946 crater. The 1946 eruption of Sakura-jima took place from a new crater on the east flank of the Minami-daké volcano, ejecting a great deal of lava flows, besides bombs, lapilli and ash. The new crater is situated on the flank, about 800 m above sea-level, some 50 m above and to the northwest of the 1939 crater (Fig. 4; Figs. 13, 14). Immediately after the eruption, the crater was measured and found to be about 50 m in diameter from north to south, being surrounded by a new cone, about 40 m in relative height[12]. Another measurement of the crater showed the diameter of its bottom to be about 45 m from north to south and a little more than 70 m from east to west[13]. The crater must have been smoking for some time after the eruption, but in Jan., 1947, it was seen to have become almost extinct without retaining any

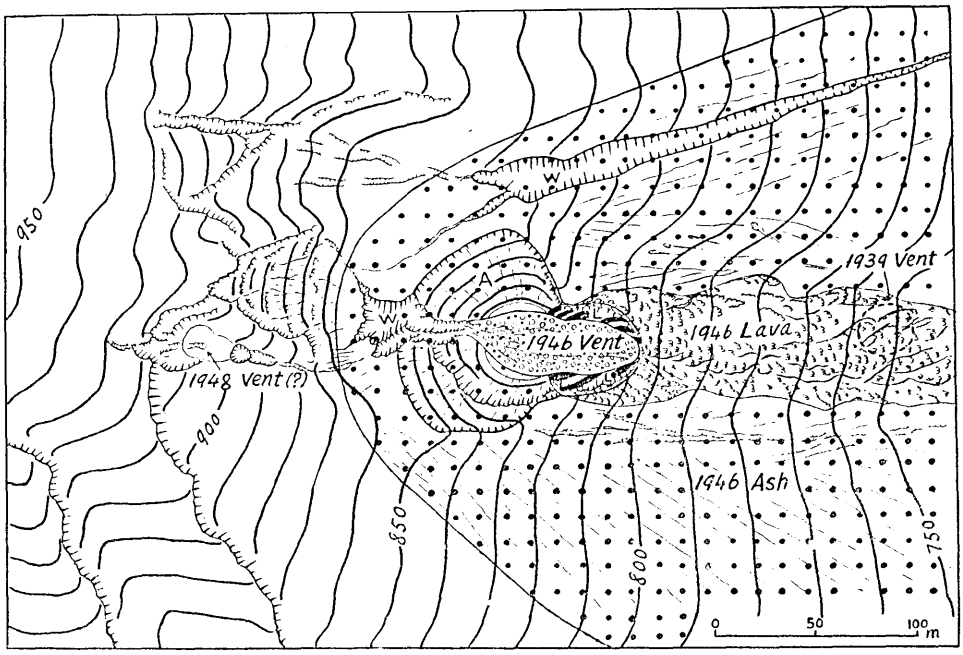

Fig. 4. Sketch map showing the present feature of the 1946 crater on the east flank of Minami-daké. A, stratified ash beds; L, lava beds. Cf. Figs. 13, 14.

12) T. MINAKAMI and S. SAKUMA, "Recent Activity of Sakura-jima." *Bull. Earthq. Res. Inst.*, **24** (1946), 179-184. (in Japanese).

13) R. MORIMOTO, "Geological and Petrological Notes on the Eruption of Sakura-jima in 1946." *ibid.*, 229-238. (in Japanese)

fumarolic activity of note except a thin emission of white vapor from crevices in its southeast wall. At the time the crater was a funnel whose walls were much higher on the west than on the east in accordance with the slope outside. Thus the bottom of the crater was something over 130 m below the west rim, while it was only about 15 m below the east rim, over which lava had run down eastwards during the eruption.

At the time of the writer's visit in Aug., 1955, the crater showed features more or less different from those mentioned. But the changes had been largely those due to non-volcanic agencies, no outflows of lava or definite eruptions having taken place from the crater since 1947. The general feature of the crater is shown in Figs. 17–19. The crater is wider in the west half than it was in 1947, attaining to about 100 m in diameter, as measured at the upper rim, while it remains almost unchanged in the east half, being a little less than 50 m across. This partial enlargement of the crater may be attributed largely to a differential erosion acting on the crater-walls. Thus the wall which surrounds the crater in the west half is composed entirely of loose ash and scoria, so that it is more liable to slip and to erosion by rainwater flowing down its face than the other wall consisting of faces of lava-sheets interbedded with somewhat consolidated agglomerate and beds of scoria. The erosion is most prominent in the west wall, resulting in the formation of a deep gully in it. The walls are very steep in all parts, without being covered by any notable amount of talus material; the walls in the west half will average 70° in slope from top to bottom; while the walls in the east half are nearly vertical, being occupied largely by lava-cliffs.

The bottom of the crater is nearly flat, covered with detritus brought in by washout through the gap in the west crater-wall, and is strewn with many blocks fallen from the surrounding walls. It is something over 60 m below the highest point of the west rim, while it is nearly on the same level with the lowest point of the east rim—the outlet of the 1946 lava-flow. Therefore, the crater-bottom must have been buried at least some 15 m deep with detritus since 1947, when it was measured to be about 15 m below the east rim. Some old lava (the first type of the Minami-daké lavas) previously exposed in the lower part of the crater-wall is visible nowhere in the present wall, because of its being buried in the crater filling. Both the lava and fragmentary material which are exposed on the present wall are those ejected by

the 1946 eruption. Around the crater, they are accumulated on a steep slope (over 25°) of the host volcano, and form an incomplete cone rising but slightly from the latter.

The fumarolic activity inside the crater appears to have diminished nearly to the point of extinction. Thus the crater-bottom shows little activity, but a feeble fumarole exists on the southeast wall, showing emission of thin vapors (about 50°C) from a crevice in the lava cliff, with a little deposition of gypsum.

From the observations made it was evident that in recent years Sakura-jima has been concentrating its activity in the summit crater of Minami-daké. Inside the crater the fumarolic activity of recent several years, of which the writer was witness in Aug., 1955, was distinctly greater than it had been during the previous ten years or so, culminating in an explosive violence once at least, and it was regarded as probable that a renewal of more intense activity would be not far off. Outside the crater, on the contrary, the small fumarole in the 1946 crater was seen to be the only one left alive in recent years, with the exception of several active fumaroles which, situated near the east and southeast rim of the summit crater, might have a direct, subterranean connection with the fumaroles of this crater. Little fumarolic activity was visible on the line of the 1914 craters or elsewhere on the east foot of Minami-daké, although formerly there was a group of active fumaroles on the east foot, near the said line and to the south of it, as could be observed in 1939. The west flank of Minami-daké has shown little sign of reawakening of activity of the volcano since the end of the 1914 eruption, no eruptions or definite fumarolic activity having taken place from the west wing of the line of the 1914 craters or elsewhere on the flank.

The explosive activity of Oct., 1955

Preliminary symptoms. The recent explosive activity which began on Oct. 13, 1955, had been forerun by nothing unusual among the surface phenomena caused by and macroscopically observable on or near the volcano. No volcanic earthquakes or rumblings were felt previously in the city of Kagoshima and vicinity; no unusual changes were detectable in temperature as well as in discharge of the hot-springs and other groundwater on the foot of the volcano. But, as mentioned above, the fumarolic activity in the summit crater of Minami-daké in Aug., 1955, was seen to have become unusually remarkable, especially

in the north and east walls. Moreover, the volcanic micro-tremors observed by the Kagoshima Meteorological Observatory at Hakamagoshi on the west foot of the volcano were much larger in number of occurrence in Aug. and Sept. than in the previous three months as follows: 112 in May, 74 in June, 114 in July, 181 in Aug. and 197 in Sept., 1955[14]. It may be said, therefore, that the coming of the recent explosive activity could be heralded within two months prior to its beginning, by the unusual fumarolic and seismic activities of the volcano.

The first explosion of Oct. 13. In the afternoon of Oct. 13, the summit crater of Minami-daké began an explosive activity which was to last for the remainder of the month and which was to exhibit a phase of activity common to the Vulcanian type of eruptions of acid andesitic volcanoes. The first explosion of the day at 14 h 52 m was sudden, without precursory rumblings and macroseismic effects, and was invisible because of the clouds with which the top of the volcano was shrouded. It was not by any means catastrophic, but was so considerable that might well be said to be the biggest of the explosions ever recorded in the history of activity at the summit crater of the volcano. Thus, at the time of the explosion, it was heard within about 50 km and as far as 250 km to the northeast of the volcano; a strong air concussion violently shook the windows of the villages on the foot of the volcano, causing some glass windows to break; an unfelt volcanic earthquake was registered by the seismograph at several weather stations in Kyushu, the maximum amplitudes of the shock being N 439 μ, E 214 μ, and Z 116 μ, as measured on the seismograms taken at the Kagoshima Meteorological Observatory[15]. The volcanic ash, ejected by the explosion, fell within about 10 km to the south and as far as 75 km to the north-northwest of the volcano; it was reported to have continued falling for about one hour from 16 h 30 m of the day at Hitoyoshi and Mizumata about 70 km to the north. In the village of Nishi-Sakurajima on the northern foot of the volcano, the ash lay more than 1 mm deep, besides some amount of lapilli, causing serious damage to various crops including citrus fruit and radishes. Cinders and blocks as large as a human head fell upon the ground a little more than 1 km around the centre of explosion. Upon falling on the southern slope of Minami-daké, some of the ejected blocks were hot enough to set fire to bush and grass at a

14) *The Seismological Bulletin* (*Jishin Geppo*), *C. M. O.*, Japan, 58 (1955), 42 (in Japanese).

15) Ibid.

few places. Funnel-shaped depressions, up to about 2 m in diameter, were formed here and there on the ground hit by large ejected blocks which, in many cases, were left half or entirely buried in the bottom of the depressions. Of the eleven students from the Kagoshima Prefectural University, who met the explosion while enjoying their lunches at the bottom of Kita-daké crater, about 1 km north of the active crater, one was killed and seven wounded by the fall of ejected blocks; more than 250 pupils and tourists were fortune in having been able to escape injury while they were half way up the mountain at the time of the explosion.

The second and subsequent explosions. The above-mentioned first explosion on Oct. 13 was followed by weaker repetitions in the remainder of the month. Thus seventeen explosions, excepting the first one, were reported as having occurred as follows: Oct. 14, two; 15, one; 16, two; 19, one; 22, two; 24, one; 25, one; 26, two; 28, one; 31, four. Of these, those on Oct. 14 to 16 and one on Oct. 22 were accompanied each time by unfelt volcanic earthquakes, as registered by the seismograph at the Kagoshima Meteorological Observatory. The black "pinos" of volcanic ash sent upward by the explosion of Oct. 16, about 12 h 45 m (Figs. 20–22), and on Oct. 31, about 8 h 20 m, were highest of all, each attaining a height of about 2500 m in the air above the top of the volcano, and the ash ejected by the latter explosion fell upon the country as far as 70 km to the east. The explosion of Oct. 26 at 6 h 30 m occurred with lightning flashes in the ash cloud rising to a height of about 2300 m. Two persons were wounded by the explosion of Oct. 15 at 15 h 08 m while visiting the south rim of the Minami-daké crater.

The explosive activity suddenly came to a halt at the end of Oct., the last explosion having taken place on the 31st at 10 h 04 m with emission of ash cloud up to the height of 1200 m. Since then the volcano had been quiescent and generally in a fumarolic condition, without any definite explosions, until Jan. 6, 1956, when the beginning of a longer period of more prominent explosive activity was reported by an explosion at 15 h 10 m. The activity of last October might be regarded as a forerunner of the main activity of this year, although the 66 days' break of activity between them requires further study before a satisfactory explanation can be reached.

The new explosion crater. On receiving the news of the first explosion of October, 1955, the writer asked the Asahi news agency to take air-pictures of the scene of the explosion before going there on

foot in the danger of subsequent explosions. The writer's request was answered on Oct. 21, with fine air-pictures as shown in Fig. 24.

This picture clearly shows that the present explosive activity broke out in the summit crater of Minami-daké, resulting in the formation of a new inner crater just at the site of the apron-like talus slope which, in August, 1955, was seen in the lower part of the north wall, spreading over the adjoining crater-floor. It is conceivable that the explosions came from near the fumarolic vent (fumarole group "A") which, previously located at the head of the apron-like talus, a little below the middle of the north wall, was seen emitting a bluish gaseous smoke.

In appearance the new crater is triple in structure, consisting of three, nested depressions. The first depression, the largest and shallowest of the three, is surrounded on the south with a low, ill-defined wall running in a half circle through the middle of the old crater-floor, while on the north it opens to the second, much deeper depression, beyond which the north wall of the old crater rises forming a high cliff. The third depression is a small funnel located in the centre of the second depression, close to the foot of the north wall, and represents the central vent of the present activity. Thus the outermost rim of the new crater may be represented by a circle about 200 m across,

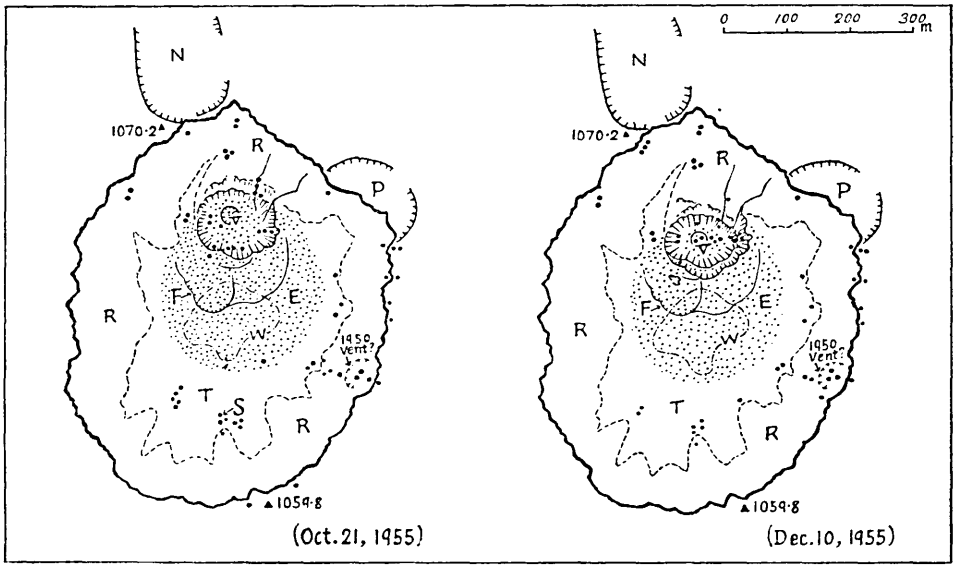

Fig. 5. Sketch map of Minami-daké crater, showing the state of its inside, as observed in Oct. (left) and in Dec. (right), 1955. V, central vent of the new explosion crater; E, the old crater-floor covered by new ejecta. Cf. Figs. 4, 23, 24.

surrounding the three depressions altogether and running through the middle of the old crater-floor on the south and the north wall on the opposite side. The first depression does not exhibit, however, those features of a crater which are caused by explosion, but appears to have been formed as effects of the explosions at the second and third depressions, probably representing a partial downthrow of the old crater-floor. On the floor of the first depression and a little to the west of the middle are three small hollows, probably of explosive origin; they appear to be united in one group with walls of separation, although their outlines are partly indistinct, being masked by a white mass suggestive of vapor-cloud rising from one of them.

The second depression is a typical explosion crater, about 110 m in diameter, surrounded on its north side with the north wall of the old crater, and on the opposite side with a rough, indented wall running from west to east across the northern part of the old crater-floor. It occupies the site of the old apron-like talus, indicating that its explosion had caused the latter to be almost entirely blown away. The upper part of the east wall of the crater appears to consist of faces of inclined beds of those portions of the talus which have been left undisturbed by the explosion. The bottom of the crater appears to be a shelf which forms the edge of the third, central depression, running almost completely around the circle and sloping toward the centre. Fumarolic activity, shown by the white cloud, is intense on the walls of the crater, especially on the south and west. The fumaroles on the south wall of the crater are seen in a east and west line which apparently represents a fissure in the wall (Figs. 23, 24).

The third and innermost depression is a funnel, about 30 m in diameter, located close to the foot of the north wall of the old crater, and represents the central vent formed by the present explosive activity. In appearance it becomes narrower downwards, and its bottom is seen covered with detritus. No estimate of the depth of the funnel is possible on the pictures, but presumably it is no more than 15 m below the south rim of the second depression.

From the disposition of the new crater it is inferred that the present explosive activity is considerable but not by any means catastrophic, not even the most powerful explosion of Oct. 13 being able to excavate any single crater sufficiently profound to clear the old crater-floor of its filling. In fact, although activity is taking place within the summit crater, it does not necessarily mean the revival of eruptive activity of

this crater, but rather represents an eccentric eruption from one of the subsidiary vents into which the central eruptive conduit of the volcano divides itself at the upper extremity, as suggested by the parasitic crateral openings and fumaroles located on and about the wall of the summit crater. In as much as the eruptions of the volcano since 1914 have occurred on the fissure line that runs from ESE. to WNW. through the north side of the summit crater, and as their vents have moved successively from the east foot toward the summit, it is conceivable that the vent of the present activity is located on or near the fissure line without conforming to the centre of the summit crater. Moreover, it is possible that the south wall of the second depression, together with the vapor fissure in it, have been guided by the said fissure line, trending east to west and nearly in parallel with the latter.

No fresh lava appears to be exposed in the new crater or elsewhere on the adjoining old crater-floor. This floor is seen covered with ash and other fragmentary material ejected from the new crater; the small pond previously occupying the central part of the floor has disappeared. Here, however, the deposit of the ejecta seems to be so thin that the trace of the pond is partly visible, as shown by the light-colored, flat ground on the south rim of the first depression.

Most of the fumaroles on the wall of the old crater appear to be as active as they were before the present eruption, and there seems to be little change in the distribution of the persistent fumaroles.

The configuration of the new crater, mentioned above as of Oct. 21, 1955, when air-pictures were taken of it for the first time, was not modified very much by the explosions in the remainder of the same month. Therefore, these explosions must have been of small intensity, superficial in nature, and not accompanied by any large quantity of ejecta, taking place at the central vent (third depression) of the new crater.

In Dec. 10, 1955, T. Watanabe made the first descent into the summit crater of the Minami-daké volcano, while studying the effects of the October explosions, according to the writer's request. The descent was made from a point on the southwest rim near the tourist viewpoint, and taking advantage of the acquired relative gentleness and stability of the wall below the rim, it was continued down to the bottom, and beyond this the south rim of the new crater was reached. During the descent, observations were made of the conditions then obtaining within the old main crater and the new subsidiary crater.

According to the observations by Watanabe, the new crater at the time of his visit to its south rim was about the same in configuration with that mentioned above as of Oct. 21. The bottom of the crater, measured with the eye to be less than 10 m below the south rim, was seen to be covered with fragmentary ejecta which revealed little of the inside structure of the crater to the observer. Considerable steam was seen rising from the inside walls of the crater, issuing from a number of small fumaroles, accompanied by a loud noise, as of hissing steam, which was nearly constant in volume. The bottom of the crater was almost free from these emanations, but it appeared to be entirely inaccessible, chiefly because of the gases issuing from the fumaroles in the surrounding walls. One of the most active fumaroles was seen in the east wall, giving off a great deal of white vapor from a fissure extending eastward from near the bottom to the upper edge of the wall. The fumaroles which, in October, appeared to have been formed along a east and west fissure in the upper part of the south wall were mostly inactive, and the fissure was indistinct. The ground about the fumaroles, active and extinct, was covered with yellow and white incrustations consisting mostly of sulphates of calcium (anhydrite) and less alumina and iron (halotrichite), to be mentioned later.

The old crater-floor on the south of the new crater was but slightly uneven, the rim of the first depression already mentioned being noticeable with a low flight of steps, less than 1 m in height, in its central part. It was covered with rock fragments thrown out from the new crater by the October explosions. These were mostly less than 15 cm in diameter and exclusively of old rocks (lavas, breccias, tuffs, etc.), more or less altered by the fumarolic action; nothing like bombs, scoria or pumice of fresh lava was found among them. In the inside walls of the old crater, there were several fresh scars and slips, probably caused by the October explosions, while most of the fumaroles appeared to be active as before, showing their apparent permanency of location. The general features of the new craters as of Dec. 9-10 are shown in Figs. 25-27.

Distribution of the fragmentary ejecta. Watanabe observed the distribution of the fragmentary material ejected by the October explosions along two mountaineering trails—the Kita-daké trail on the northwest side of Kita-daké and the Minami-daké trail on the south side of Minami-daké. According to him, nothing identifiable as the ejecta of the October explosions remained on the foot of the volcano, but in ascending

the mountain along either trail, the ejecta were found in masses of constantly increasing density and size as the summit was approached. Thus, on the upper northwest slope of Kita-daké were cinders, 1–3 cm in diameter, besides ash and sand, covering fallen leaves on the ground; on the floor of the Kita-daké crater were ejecta, up to about 20 cm in diameter, some of the large ejected blocks being half buried by their fall on the ground; finally, on the floor of Naka-daké crater, there was naturally the densest distribution of the ejecta, and there were scattered blocks, something over 30 cm in diameter, besides smaller blocks and cinders without number (Figs. 28, 29). The ejecta on the south slope of Minami-daké appeared to be less dense in distribution and more restricted in the range of fall than those on Kita-daké. Thus, ejected blocks, about 20 cm in diameter, were found only sparingly on the upper slope near the south rim of the Minami-daké crater, although smaller blocks and cinders were seen distributed more densely as far as halfway down the slope (Figs. 30, 31).

The bulk of the ejecta, especially most of the ejected blocks and cinders, were of the first great explosion of Oct. 13, which took place under the southerly wind, hence the ejecta being distributed more extensively and more abundantly in the region to the north of the active crater than in the opposite region. However, the deposit of these ejecta was less than a few centimeters in average thickness everywhere outside of the Minami-daké crater, and it appeared rather to be ephemeral without staying as a permanent bed distinct from the underlying old rocks. An estimate made by the Kagoshima Meteorological Observatory has shown that the total mass of the detritus ejected by the explosion of Oct. 13 is something over 90,000 tons (55,000 m^3), exclusive of a small mass of the ash that fell in the region farther than 5 km from the crater[16]. As the second and subsequent explosions in the same month were comparatively so unimportant as to be noticed only as small ash-explosions, they must have not contributed much to the deposition of the ejecta. Moreover, so far as observations go, the products of these explosions are exclusively accessory in petrographic character; among them are found neither pieces of a juvenile lava nor anything like accidental ejecta of a rock foreign to the volcano. Therefore, to say nothing of each of these explosions, the October activity as a whole is comparatively small in intensity and superficial in nature, originating

16) The Kagoshima Meteorological Observatory, "The Sakura-jima Explosion of Oct. 13, 1955." *The provisional report*, No. 3, Nov., 1955 (in Japanese).

in a shallow depth, possibly less than 1000 m below the bottom of the Minami-daké crater. The activity may be put at grade II of the writer's intensity scale of volcanic activity, classified according to the volume of solid ejecta[17].

The explosive activity of this year, which has been taking place reccurrently for months since Jan. 6, is not much greater in intensity of explosion than the activity of last October, but is remarkable in that it has entered upon a phase of true eruption in the sense of being accompanied by ejection of bread-crust bombs and pumice of a juvenile lava. The history of this activity and its general feature will be mentioned later, together with the petrography of the material ejected by the explosions since last October.

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22. 桜島火山の最近の噴火について (I)

地震研究所 津屋弘達

桜島火山は昭和 30 年 10 月 13 日爆発を開始し，同月末日までに 17 回ほどそれをくりかえして一旦静まつた．しかるに昭和 31 年 1 月 6 日に至つて爆発を再開し，その後，毎月 10 回内外それをくりかえして，比較的大きいもののみでも，前年の 10 月 13 日から数えて 4 月 9 日までに 50 回，5 月 20 日までには 80 回ほどに達した．(その後の情報によると，爆発はなお止まず，9 月中頃には 100 回に達し，微弱なものを加えると，5000 余回も数えられたという．)

筆者は桜島及び阿蘇火山の活動状況を近年特に注目していたが，桜島火山については，昨年 8 月に今回の噴火直前の活動状況を観察し，10 月 13 日に爆発を開始してからは，朝日新聞社の好意によつて 10 月 21 日に撮影された爆発現場の空中写真の数枚によつて，爆発状況を調査することができた．その後 12 月には，筆者の要請によつて渡辺(佐)技官が 10 月爆発後の一時的静穏期の状況を踏査し，噴火口内にまで近寄つて観察した．更に本年 4 月上旬には，筆者は 1 月 6 日に再開された反復爆発活動の現場を調査し，昨年 10 月及び本年 1～2 月頃の旧岩屑のみを噴出した表面的噴火から，新熔岩の軽石，パン皮状火山弾を伴う本格的噴火に移行した事実を初めて確認した．本文はこれらの調査観察の結果の報告である．

有史時代の桜島火山の噴火は南岳の活動のみに限られている．同火山の構造を見ると，北岳，南岳，中岳の順に形成された事がわかるが，南岳と中岳とは北岳より一段と新しいもので，南岳の上部熔岩と中岳熔岩とは殆ど同じ性質を示すものである．恐らく中岳は南岳火山の山頂火口の北縁近くに起つた偏心噴火によつてできた寄生火山であろう．今回の噴火は南岳山頂火口の北壁下で起つているが，もう少し北方に偏つて起れば中岳火口底を破つたにちがいない．

有史時代の噴火は西暦 8 世紀前半，15 世紀後半 (文明年間)，18 世紀後半 (安永年間)，20 世紀前半 (大正・昭和) の 4 期に大別される．第 1 期及びこれらの 4 期に入らない単一噴火については，噴火地点やその状況が明かでないが，第 2，3，4 期の噴火はそれぞれ明らかに南岳山頂火口を中心

17) H. TSUYA, "Geological and Petrological Studies of Volcano Fuji, V," *Bull. Earthq. Res. Inst.*, **33** (1955), 379.

とする放射線の両翼に起つた両側噴火である．從つて，これらの放射線は南岳火山を切る火山構造線であるにちがいない．第 2 期及び第 3 期の活動を起したそれぞれの火山構造線の北東翼は南岳から延びて，北岳の北東麓にまで及んだので，これらの活動では北岳の山体上にも噴火が起つたが，これらも北岳火山自身の活動ではなく，南岳火山の活動と見るべきものである．

第 4 期活動は大正 3 年の大噴火に始まつた，この噴火も南岳山頂火口を通る西北西・東南東方向の構造線の東西両翼に起つたもので，山頂火口或はその附近では単なる爆発すら全く起らなかつた．その後昭和 10 年までの 20 年間，噴気作用以上の活動は全く見られなかつたが，同年 9～10 月に山頂火口の北東壁下で約 1 ヶ月の間，小爆発が反復し，同時に東麓の大正 3 年火口の一つも活動した．これによつて大正 3 年以来一旦休止していた南岳火山の噴火活動が同じ構造線の東翼で再発し始めたことが推定されるが，その後次第に盛んになつた噴火活動の推移によつて更に実証された．すなわち昭和 10 年の活動後，南岳の噴火は断続的に行われ，昭和 14 年，15 年，16 年，17 年，21 年，23 年，26 年等にそれぞれ噴火活動が南岳の東側から頂上火口に至る間に起り，昨年 10 月以降の最近の噴火となつた．これらのうち，新熔岩流或はその断片の噴出を伴う本格的噴火（大正 3 年，昭和 14 年，21 年，30～31 年）は上述の構造線の東翼上を山麓から山頂火口に向つて順次噴出地点を移動した．昭和 15, 16, 17 年及び昭和 23, 26 年の活動地点及びその性質は明かでないが，昭和 23, 26 年の活動は上述の順列に入るようである．（第 1 図参照）．特に昭和 26 年の活動は山頂火口東壁に起つた爆発であつたらしく，昭和 21 年撮影の写真（第 9 図）では，この地点に爆発孔らしい凹みも噴気活動も見られないが，昭和 23 年撮影の写真（第 15, 16 図）では，そこにこれらが明かに見られる．

これら昭和 10 年以来の噴火活動に伴つて噴出した新熔岩流或はその火山弾，軽石などと大正 3 年噴出の新熔岩とは岩石学的性質の上で殆ど差別のない複輝石安山岩である（部分により或は時により，少量の橄欖石を伴うこともある）．從つて，大正 3 年以来の桜島火山の噴火活動は地下の同じ熔岩体が南岳を西北西・東南東方向に横切る構造線に沿つて上昇しようと努めている表われで，それに伴つて噴火を起し得る熔岩体の中心先端つ位置が南岳東麓から山頂火口に移動して来たものと考えられる．

かくして，最近の噴火は山頂火口の北壁下で，上述の構造線上にほぼ位する地点に起つた．昨年 8 月には，この地点には北壁中部から火口底に向つて拡がるエプロン状の崖錐があり，その頭部に，恐らく噴気の侵蝕作用によつてできたと考えられる小火口状の孔があつて，白色噴気の他に，青紫色の恐らく特に高温のガス煙が認められた．最近の噴火によつて，このエプロン状崖錐が全部噴きとばされ，北壁下に新しい爆発火口ができた（第 23～27 図参照）．この火口はほぼ円形であるが，東西方向の裂線に多少支配されており，新しい噴気孔がこの方向に列んでいる傾向が見られる．昨年 8 月旧火口底に水溜りがあつたが，10 月の噴火によつて全く干上がり，新拋出岩屑に蔽われた．この旧火口底には，今回の噴火の前後共に噴気作用が全く行われていないが，周壁，特に北壁から東壁にかけては数多くの噴気孔があり，盛んに白煙を上げている．それに反し，南岳の東側には，山頂火口の縁辺を除き，噴気活動は殆ど止まつている．昭和 21 年噴火口も既にその熔岩流出の銚子口まで，雨水によつて押出された岩屑に埋まり，南側火口壁の熔岩の割目から出る 50°C 内外の淡い水蒸気が認められるのみである．南岳西側の大正噴火口附近には噴気活動は全く見られない．從つて，南岳の少くとも最近数年間の活動は専ら頂上火口に集中されて来たと考えられる．しかし，その火口底の中央は固く閉塞された状態にあり，今回の噴火はこの火口の本来の中心活動というよりむしろ，大正 3 年以来の構造線上の活動がたまたまこの線が頂上火口を横切る地点に移動して来たのであろう．南岳山頂火口からは，有史時代に熔岩流が噴出した記録はなく，また現地の熔岩分布の状況にもそのような証跡はない．しかし今回の噴火が上述のような性質のものであるとすると，その構造線は大正 3 年，昭和 21 年の噴火で明かなように，熔岩流出を伴うことがあるので，もし噴火圧が熔岩を山頂火口まで押上げるに十分になれば，熔岩流出を起す可能性がある．

最近の噴火は今年 1 月 6 日に再開してから数ヶ月に及び，何時静まるか予断を許さないが，その噴火口は昨年 10 月以来殆ど変化していない．今後この活動が当分続くとしても，東西構造線の西翼，即ち南岳の西側にその中心が移動すると考える理由はなにもない．

昨年 10 月噴火によつて拋出された岩屑は新しい熔岩の断片を雑えていない．10 月 13 日第 1 回の爆発が最も大きく，その時の拋出物は火口北翼の中岳，北岳方面に多く散布された．同年 12 月の

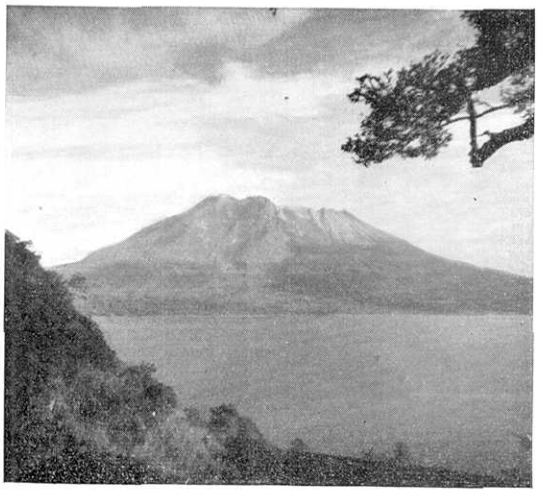

Fig. 6. Sakura-jima in 1955. View from Kagoshima City, looking east. Dec.11, 1955. Photo T. Watanabe.

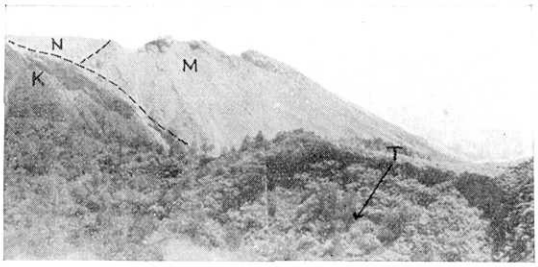

Fig. 7. The west flank of the mountain, showing the structural relation of the three peaks—Kita-daké (K), Naka-daké (N), and Minami-daké (M). T, one of the 1914 craters (No. I in Fig. 1), now overgrown with bush. April 13, 1956.

Fig. 8. Sakura-jima from the air (northwest), showing all three summit craters —Kita-daké (left), Naka-daké (middle), and Minami-daké (right). March 6, 1955. Photo I. Muraoka.

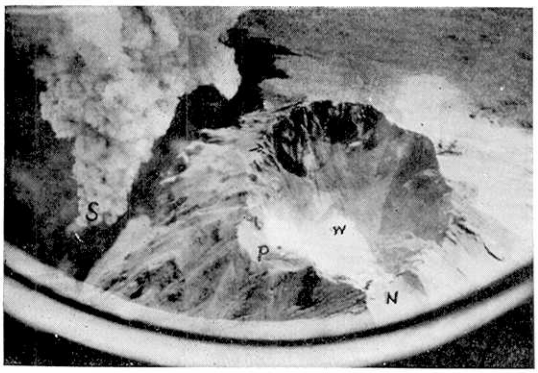

Fig. 9. The summit crater of Minami-daké from the air (northeast), showing the state of its inside in 1946. N, Naka-daké crater; P, ruin of an old crater; S, the 1946 crater in eruption. Arrow indicates the site where an explosion vent (B in Figs. 11, 12) was opened in 1950(?). March, 1946.
Photo The Asahi.

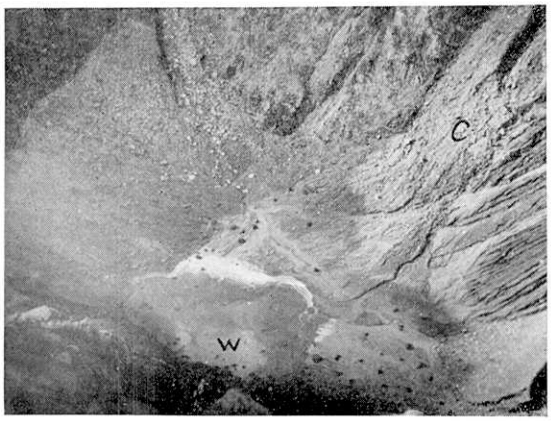

Fig. 10. Bottom of Minami-daké crater, looking down from its east rim. Dec., 1939. Cf. Fig. 11.

Fig. 11. Ditto., looking down from the east rim. W, pool of water at the bottom; C, apron-like talus in the lower part of the north wall. Aug. 17, 1955. Cf. Fig. 4.

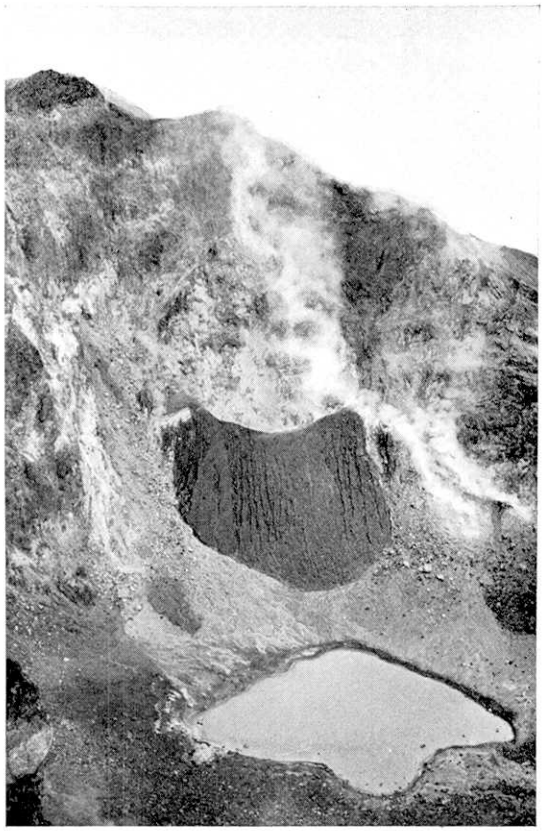

Fig. 12. Ditto., looking north from the south rim of the crater. In the background (upper left) the summit of Kita-daké beyond the rim of Naka-daké crater. Nov., 1954. Photo Y. Kitahara.

Fig. 13. Minami-daké from the air (east), showing its summit crater and the 1946 crater (S; No. 9 in Fig. 1) and lava flow (L) on the east flank. Oct. 21, 1955.
Photo The Asahi.

Fig. 14. Ditto. (closer view). Oct. 21, 1955.
Photo The Asahi.

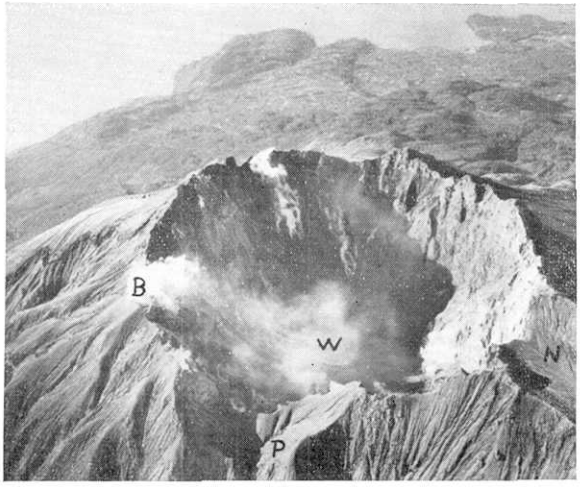

Fig. 15. The summit crater of Minami-daké from the air (northeast). P, ruin of an old crater (cf. Fig. 2); W, pool of water at the bottom of the crater; N, Naka-daké crater; B, vapor cloud rising from fumaroles in the 1950(?) explosion vent on the east wall of the crater. 1953. Cf. Fig. 16. Photo The Asahi.

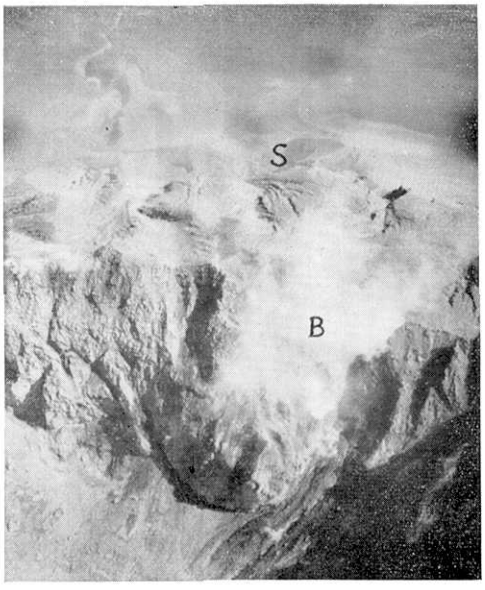

Fig. 16. The east wall of the summit crater of Minami-daké from the air (southwest), showing vapor cloud rising from fumaroles in the 1950(?) explosion vent. S, the 1946 crater. Oct. 21, 1955.
Photo The Asahi.

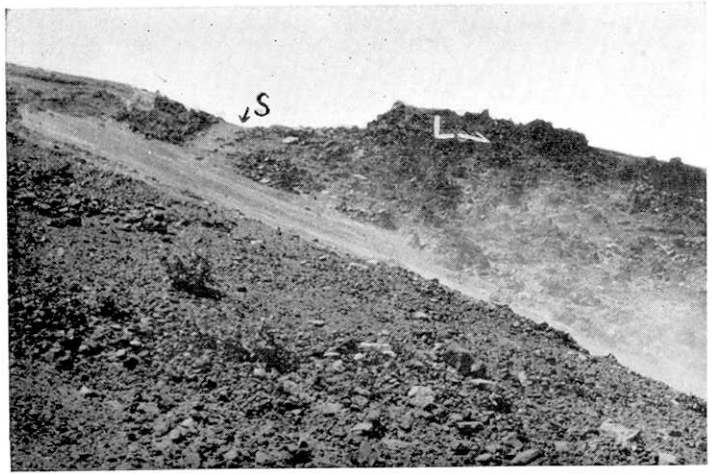

Fig. 17. The 1946 crater (S) and lava flow (L), looking northeast. Aug. 17, 1955.

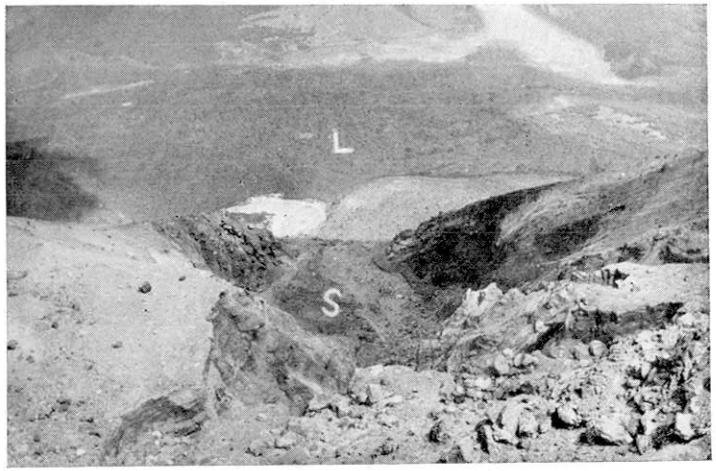

Fig. 18. The 1946 crater (S), looking down from its west rim. The lava flow (L) from the crater in the background. Aug. 17, 1955.

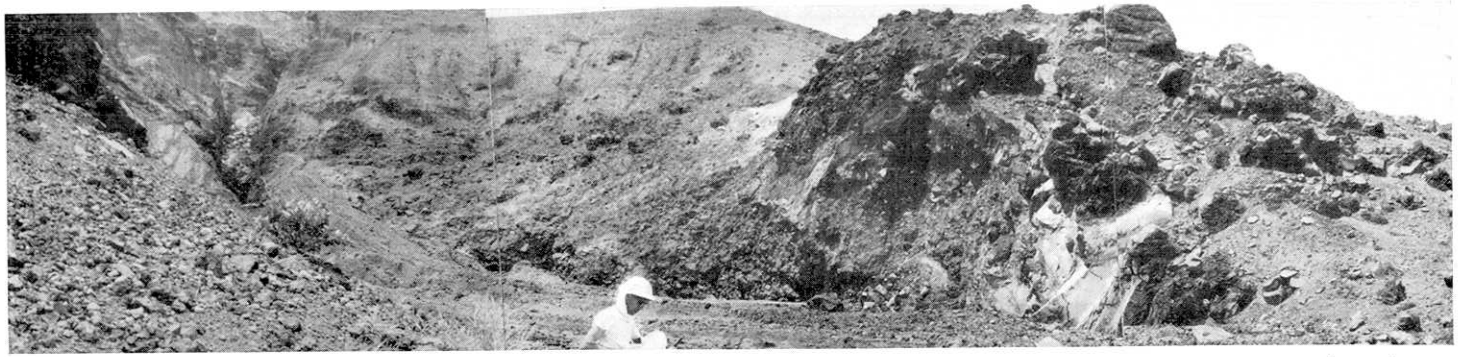

Fig. 19. The 1946 crater on the east flank of Minami-daké, showing its floor filled up with detritus. Looking east from the lowest east rim. Aug. 17, 1955. Cf. Fig. 3.

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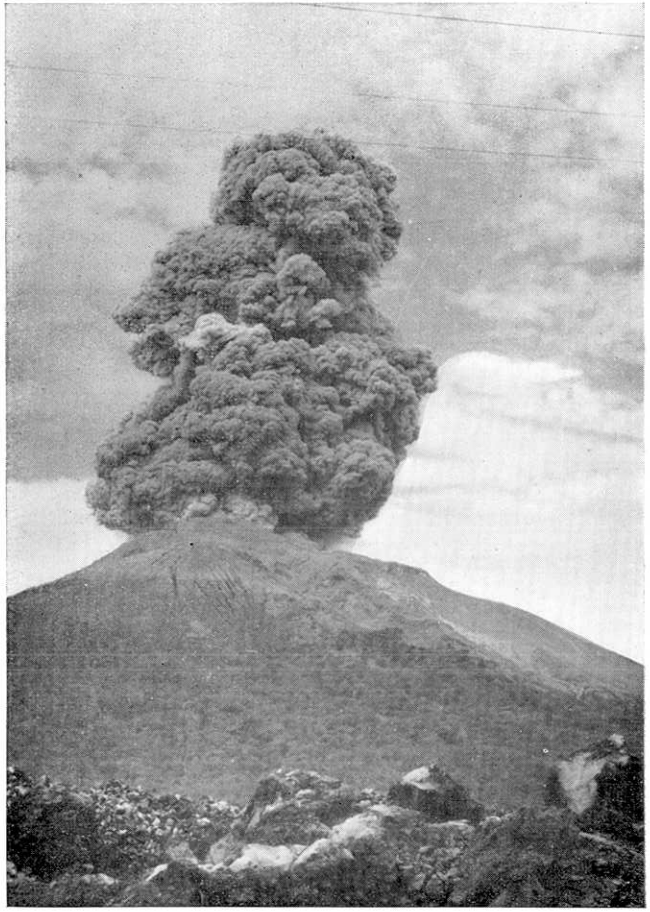

Fig. 21. Eruption of Sakura-jima on Oct. 16, 1955, at about 12h 40m, looking north from the southern foot of the mountain. The 1946 lava in the foreground. Photo I. Muraoka.

Fig. 20. One of the explosions of Sakura-jima in Oct., 1955. Looking east from Kagoshima City. Oct. 16, 1955. Photo by courtesy of I. Muraoka.

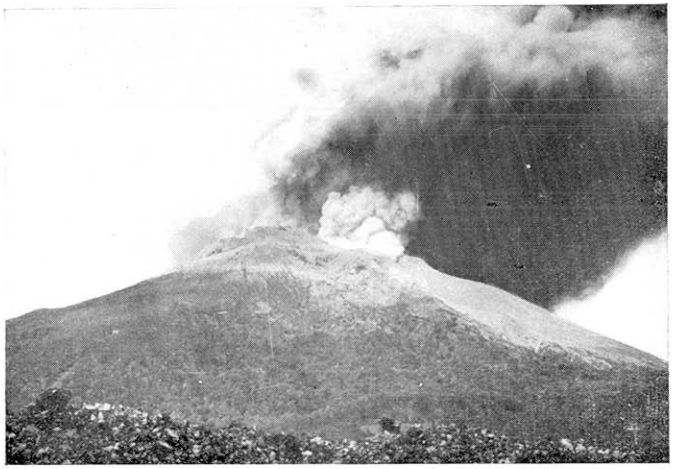

Fig. 22. Same view as Fig. 21, taken about 10 minutes later. Photo I. Muraoka.

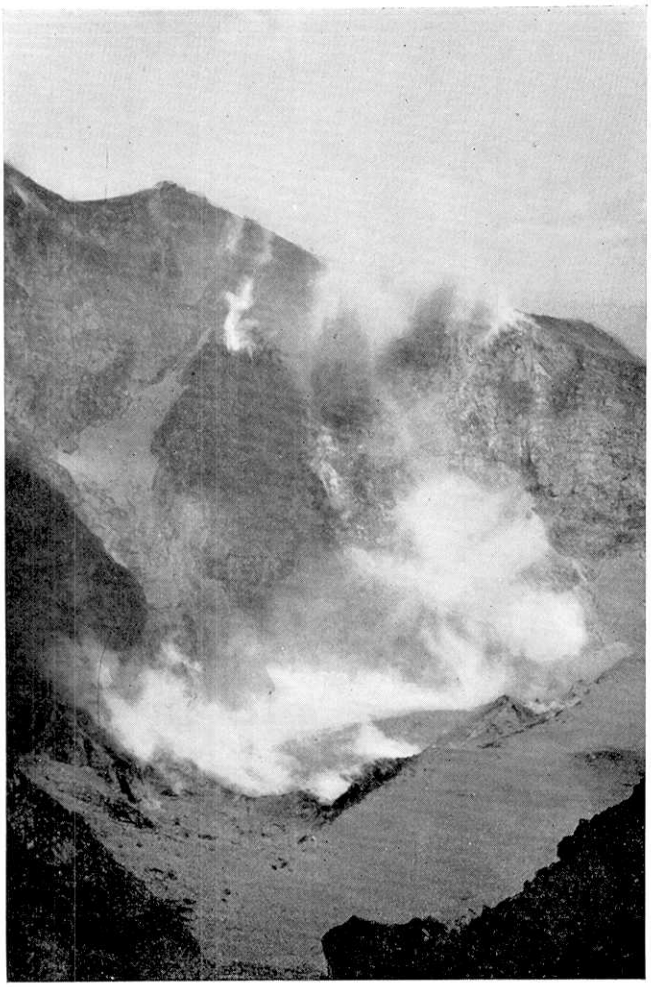

Fig. 23. The active explosion crater, looking down from the south rim of the summit crater of Minami-daké. Oct. 15, 13h, 40m, 1955. Cf. Fig. 12.

Photo Y. Kitahara.

Fig. 24. The active vent in the summit crater of Minami-daké from the air (west). N, Naka-daké crater; B, fumaroles in the 1950(?) crater; P, ruin of an old crater; W, a part of the water pool, now dried up. V, active vent. Oct. 21, 1955.

Photo The Asahi.

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Fig. 25. The active vent, looking down from the south rim of Naka-daké crater. Dec. 10, 1955. Photo T. Watanabe.

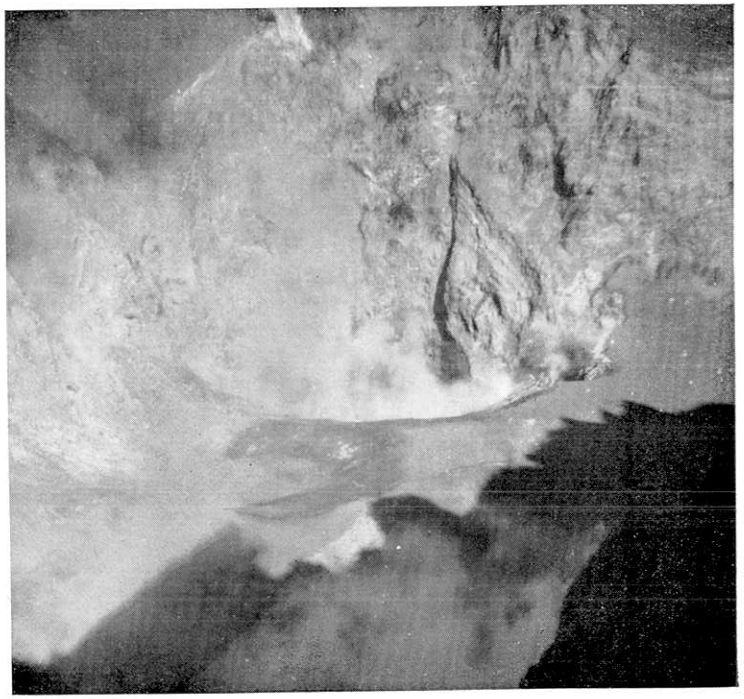

Fig. 26. The active vent, looking down from the south rim of the summit crater of Minami-daké. Dec. 11, 1955. Photo T. Watanabe.

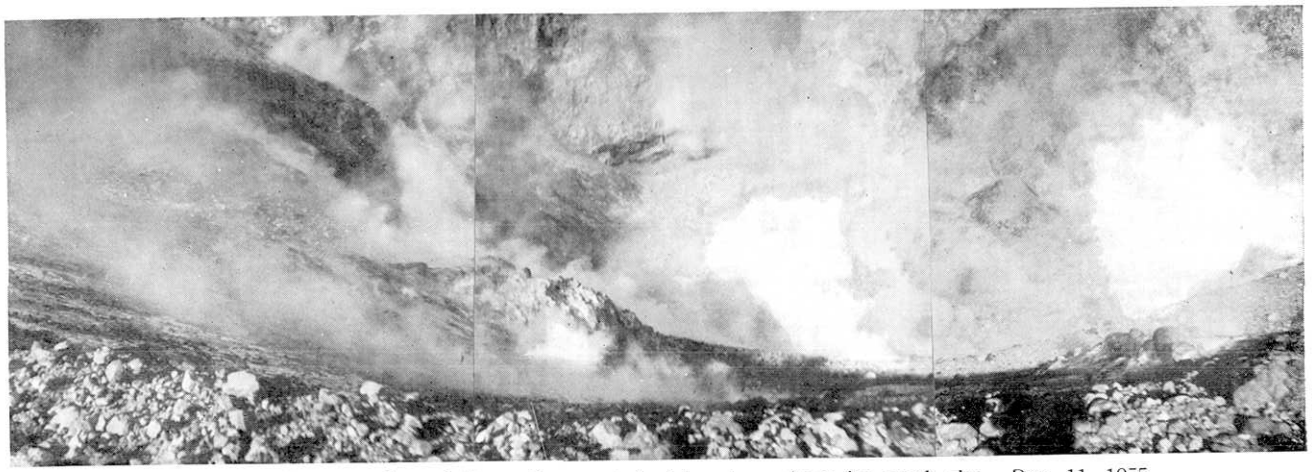

Fig. 27. Close-up view of the active vent, looking down from its south rim. Dec. 11, 1955.
Photo T. Watanabe.

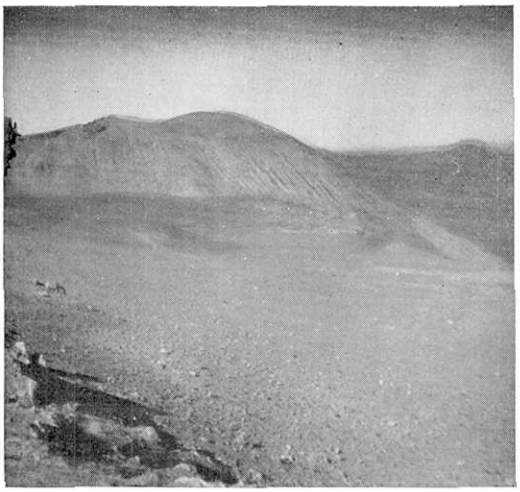

Fig. 28. The floor of Naka-daké crater, looking north, showing ash and cinders thrown out by the explosions of Oct., 1955. Kita-daké in the background. Dec. 10, 1955.
Photo T. Watanabe.

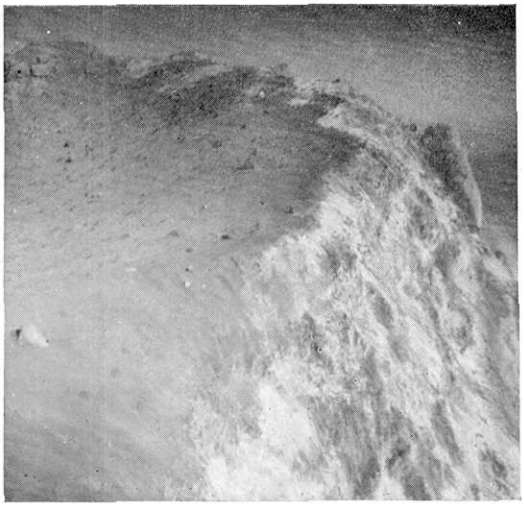

Fig. 29. The south rim of Naka-daké crater (upper edge of the north wall of Minami-daké crater), showing deposit of ash and cinders (dark-colored) of Oct., 1955. Dec. 10, 1955.
Photo T. Watanabe.

Fig. 30. A bowl-shaped hollow (about 1 m in diameter) formed by the fall of an ejected block on the pumice-covered south flank of Minami-daké. Dec. 11, 1955.
Photo T. Watanabe.

Fig. 31. An ejected block (about 20 cm in diameter), with a hollow formed by its fall on the grass-covered ground of the south flank of Minami-daké. Dec. 11, 1955.
Photo T. Watanabe.

調査でも，拋出物は中岳，北岳方面に多く，南岳の南側方面には少く分布していた．鹿児島地方気象台の報告によると，第 1 回の爆発による拋出物の総量は約 9 万トン余であつた．その後 10 月中の爆発による拋出物を加えても，その総量は大して多くない．従つて，昨年10月の活動は筆者の設定した噴火強度階の II に相当する．

この活動によつて拋出された岩屑には，南岳の頂上火口縁を造る熔岩に相当するものが多少あるが，大多数はそれと異る岩質のもので，観察した限りでは凡て同一の顕微鏡的構造を示し，噴気作用によつて変質し，二次的の珪酸鉱物，石膏などを伴うものが少くない．これらの拋出物については，今年 4 月に初めて確認された新熔岩の火山弾，軽石などと共に，本文の続篇で岩石学的性質を記述する．