27. *The Eruption of Miyake-sima, One of the Seven Izu Islands, in 1940.*

Geological Observations of the Miyake-sima Eruption of 1940. (II)[1]

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III. Topographical Changes.

THE ZONE OF FLANK ERUPTION.

As described in the preceding chapter, the present activity of Miyake-sima was a multiple eruption, consisting of a flank eruption and a summit eruption. It lasted for a period of 25 days from July 12 to August 5, 1940, during which interval a great number of explosions occurred, resulting in several topographical changes, mainly owing to accumulation of newly-ejected matter in the disturbed areas, although none of the explosions was sufficiently violent to alter radically the form of the mountain or to destroy any considerable part of it. The main topographical changes caused by the flank eruption of July 12～13 were the formation on the northeastern side of the somma, besides the fissures, of new parasitic craters (including the new parasitic cones) and new lava fields.

New parasitic craters and new parasitic cones.

1. Cinder cone A. This cone, situated at the highest level, about 430 m above the sea, and in the zone of the flank eruption, lies on a ridge sloping about 30° northeastward near the boundary between Kamituki and Tubota. It is not a perfect conical mound, but forms a shoulder on the steep slope of the former ridge, so that although its northeastern half is of conical shape, rising about 30 m above the ground of the former ridge, the other half constitutes the slope of this ridge itself (Fig. 51). The central part of the cone has an oval crater, about 50 m deep, the longer and shorter axes of which are about 150 m from northwest to southeast respectively. Except the northeast wall, which slopes about 40°, the inside walls of the crater are almost vertical. The crater-

1) Continued from page 294 of this Bulletin, **19**, (1941).
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floor, which is circular and flat, about 30 m across, is covered with detritus that fell from the surrounding walls.

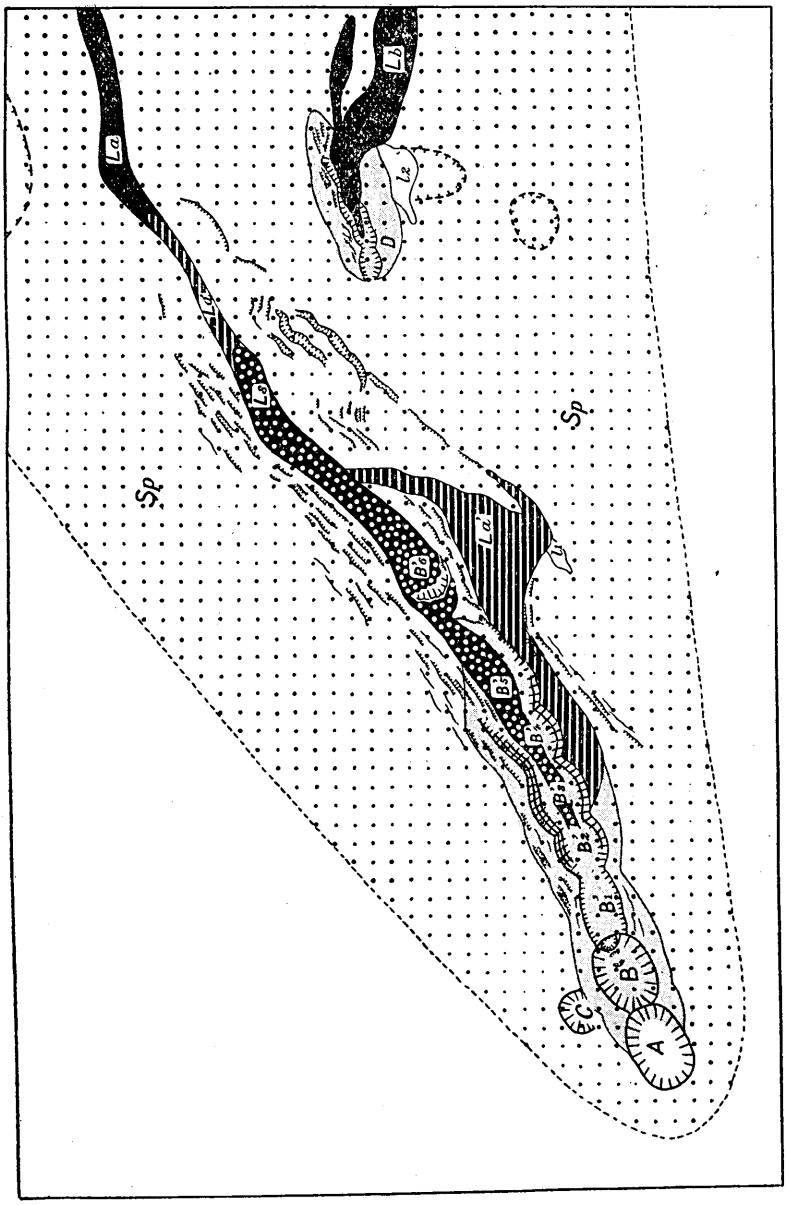

Fig. 50. Sketch-map showing the western part of the zone of flank eruption.
A~*D*: New craters. *La*: Akabakkyô lava (fluent). *La'*: Akabakkyô lava (blocky). *Ls*: Debris flow (lapilli and bombs). *Lb*: Yoridaisawa lava. *Sp*: Volcanic sand, lapilli and bombs. l_1, l_2: Dammed ponds.

The southwestern inside wall of the crater, which is a vertical section of the ridge on which the crater opened, exposes three layers, 1~5 m thick, of old lava-flows (olivine-basalt) intercalated with layers of reddish-brown scoriaceous lapilli. The lower half of the inside north-

eastern wall also exposes the same old beds, while its upper half is formed of new ejecta.

The solid materials thrown out of this crater consist of accessory rock-fragments and juvenile ejecta (lava-blocks, bombs, and scoriaceous lapilli). The accessory ejecta, which are nothing but fragments of the old beds just referred to, are accumulated in a small area on the ridge adjoining the southwestern side of the crater. The juvenile ejecta are accumulated for the most part on the lower side (northeast) of the crater, forming the one-sided conical mound.

From the distribution of the ejecta, it is inferred that the eruptions at A first shattered one part of the old ridge, followed by ejection of the shattered portion as accessory ejecta and later by that of juvenile materials.

When the writer first visited the crater on July 19, 1940, no incandescent material was seen anywhere in or around the crater, although white vapor-clouds were rising from several places near the northern and shouthern crater-rims. When the writer made his second trip to the crater on Oct. 25, the same year, feeble fumaroles were still active at a number of places on the northeastern side of the crater.

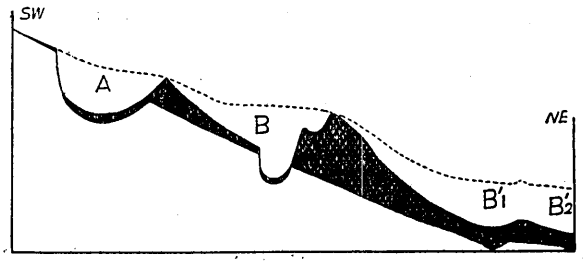

Fig. 51. Diagrammatic section of new parasitic cones *A* and *B*. New ejecta are shown in black.

2. Cinder cone B. Adjoining the northeastern side of *A*, and lying on the same old ridge, is another cinder cone *B* of somewhat smaller size, the central part of which has a circular crater of an average diameter of about 150 m. The inside southwestern wall of the crater, whose slope varies from 30° to 50°, deeply cuts the northeastern flank of cone *A*, the wall between the craters *A* and *B* consequently forming a sharp crest of such narrow surface as to be hardly passable. The northern and southern walls of this crater are nearly perpendicular, while the northeastern wall is terraced with a shallow side crater, about 30m wide. The lower part of the main crater narrows, forming a cylindrical pit, about 30 m, the depth of which, on July 19, was beyond measure. Owing to infallen detritus, the bottom of the pit, on Oct. 25, was about 50 m from the upper rim of the crater. The surrounding wall of the pit exposes an old lava which may be the northeastern extension of one of the lavas that are exposed on the walls of crater A.

Cinder cone B consists largely of juvenile material (lava-blocks, bombs, and scoriaceous lapilli), although a few accessory rock-fragments are found among the juvenile ejecta. On July 19, vapor was issuing from a number of fumaroles in and around the crater-bowl, while on Oct. 25, vapors continued to rise from several places on the crater-wall and from the numerous fissures on the outer slope of the cone.

3. Craters $B_1'\sim B_6'$. Adjoining the northeastern side of B, there is a trough-like depression, 50~150 m wide and about 50 m deep, running northeast for a distance of about 700 m. This depression consists of six new craters, B_1', B_2',.....B_6', which are arranged in this order from southwest to northeast. Crater B_1' thus lies at the southwestern end of the depression, next the northeastern side of cone B, the wall of the crater deeply cutting the flank of the latter. Crater B_6', the most northeastern member of the crater group, lies about 180 m above the sea, in the valley on the boundary between Kamituki and Tubota, while the other craters are aligned between B_1' and B_6'. Although the adjoining two of these craters open into each other, they are separated either by a low ridge between them or by a cliff, showing difference in level of their bottoms. Besides, the northern and southern walls of one crater join the respective walls of the adjoining crater, forming cusps that face each other at the boundary of the two craters.

The B' craters were opened by the recent eruption in the valley that lies on the border between Kamituki and Tubota. This valley had become wider as well as deeper downward from the end of the ridge on which stand cones A and B, with the result that the material exposed on the northern walls of these craters are exclusively new ejecta which, upon being thrown out of these craters, were piled thickly on the floor of the valley. The ejecta, as observed in the crater-walls, are mostly fragmentary material consisting of reddish-brown, scoriaceous lapilli, bombs, and lava-blocks, besides two sheets of a grayish compact lava, intercalated by layers of the fragmentary ejecta. On July 19, 1940, when the writer saw the craters for the first time at close range, the interior of some of the clefts here and there in the crater-walls was seen to be at red heat.

The B' craters are arranged, together with A and B, in a straight, SW–NE line, whose northeastern extension reaches the northern part of the bay of Akabakkyô, passing through the lower course of the valley at the boundary between Kamituki and Tubota, and whose southwestern extension lies almost in the direction of Oyama, the central cone. This distinct alignment of craters suggests the existence of a fracture-line in the said direction through the volcano. During the recent activity,

no eruption occurred anywhere on the supposed fracture-line, southwest of *A*, the central cone excepted; neither on the same line, northeast of B_6', the bay of Akabakkyô excepted.

It is inferred that crater B_6' lay where the flank eruption of 1940 originally started. Thus, as already mentioned in the preceding chapter, according to Kano, who lived on the northern side on the borders of Kamituki and Tubota, dark smoke began to rise a few minutes before 8 pm, July 12, from the valley ahead (southeast) of his house. Although he managed with difficulty to reach a place of safety, his neighbour, who lived in a house about 200 m southwest of B_6', was missing, together with five members of his family.

4. Crater C. Adjoining the northern side of *B*, and lying on the southern slope of a ridge that runs parallel with the ridge on which lie *A* and *B*, there is a new horseshoe-shaped crater, about 50 m in diameter. This crater is surrounded on its northern side by an almost perpendicular wall exposing, besides layers of old reddish-brown lapilli, a sheet of old lava which is the northern continuation of the lava that is exposed in the middle of the southwestern crater-wall of *A*; while it is breached on its southern side, the crater-bottom communicating by means of a gap in the wall with the northern flank of *B*.

From the distribution of new ejecta in and around crater C, it is inferred that this is merely an explosion-crater, whose activity was of fairly short duration. Thus, although new ejecta (scoriaceous lapilli, bombs, and blocks of juvenile lava, and accessory rock-fragments) have accumulated thickly in and around crater C, they are mostly ejecta from the neighbouring craters *A* and *B*. Furthermore, the distribution of ejecta from *C*, *A*, and *B*, shows that the activity of these craters should have subsided in the order mentioned. On July 19, when the writer made his first visit to the crater, no steam vent was found either on the crater-floor or on the crater-walls.

5. Cinder cone D. At intervals of about 500 m east of B_6' and on the gentle slope about 140 m above the sea, adjoining the southern side of the boundary valley between Kamituki and Tubota, there is a new mound *D*, about 30 m above the old ground, facing the old parasitic cone Daihannya-yama, lying beyond the Yoridai-sawa valley. Although, when viewed from a distance, east or west from it, the mound looks like a typical cone, it is a ridge-like mound,

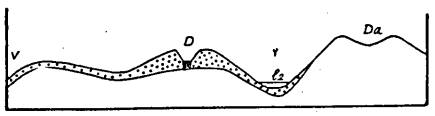

Fig. 52. Diagrammatic section of cone *D*. *Da*: Daihannya-yama, an old parasitic cone. *Y*: Yoridai-sawa. *V*: Boundary valley between Kamituki and Tsubota. l_2: Dammed pond.

about 50m wide and 200 m long, running in a ENE–WSW direction. The crater which, on this mound, is a trench-like stretch, is about 30 m wide and 30～50 m deep, running for a distance of 200 m from the WSW end of the ridge ENE to the opposite end. The north and south walls of the crater form almost perpendicular cliffs, exposing a massive deposit of new ejecta. Judging from exposures in the crater-walls, the western part of the ridge is built up of reddish-brown, scoriaceous lapilli and bombs, while in its eastern part these ejecta are covered with a flow of block lava that descends eastward into the Yoridai-sawa, whence the inference that the eruption at *D* took place in a rift-crater that opened afresh on the gentle mountain slope, and that the successive ejections of scoriaceous lapilli and bombs from the crater were followed by an outflow of lava from the lower, eastern part of the same crater.

The old ground upon which the new mound *D* rests is composed of yellowish-gray ash-beds dipping less than 10°E, as observed in the south wall of the western end of the rift-crater, where the beds are exposed in the lower half of the crater-wall, and where they are overlain by a deposit of new ejecta (scoriaceous lapilli and bombs). Underneath the ash-beds, as observed in an exposure in the Yoridai-sawa between *D* and Daihannya-yama, lies a deposit of volcanic breccia, about 20 m thick, followed by a lava-flow of augite-olivine-basalt. These old rocks are met with as accessory fragments, but sparsely in the ejecta from the crater of *D*.

At the end of July, the ground in the rift-crater, which contained numerous vents discharging steam and gases, was very hot, while three months later (end of October), it had everywhere cooled down with the exception of a few feeble fumaroles. But even at the latter time, there were numerous fumaroles on the ground outside the crater, particularly on the crest of the northern rim of the crater, where they were developed on fissures running parallel to the crater-rim as well as in a SW–NE direction. There were also some fissures discharging hot gases, the interiors of which former were red hot.

6. Rift-crater E. At a distance of about 500 m ENE of *D*, on the floor of a gully, called the Yomogiga-sawa, there formed a new rift-crater *E*, which is a trench-like stretch, about 100 m long, 10～15 m wide, and 10 m deep, consisting of seven small vents running ENE. Although two of the seven vents in the rift-crater communicate with each other without any distinct partition-wall, they are distinguished from each other by a step's difference in the depth of their floors.

The ejecta from the crater, which former are mostly black to grayish scoriaceous lapilli of juvenile and almost aphanitic lava, are relatively

Fig. 53. Sketch-map showing the eastern part of the zone of flank eruption. *EH*: New craters. *La*: Akabakkyô lava. *Lb*: Yoridai-sawa lava. *Lc*: Hyôtan-yama lava. *Sp*: Volcanic sand, lapilli, and bombs. *Sb*: Lapilli and bombs ejected from Hyôtan-yama craters *G* and *H*. *I*: Coast-line before the eruption of July 12~13, 1940. *II*: Coast-line immediately after the eruption. *III*: Coast-line in the middle of Sept., 1940. *ls*: Sitori lake.

small in amount; for, as observed in the exposure in the southern wall of the crater, they lie only about 2m deep upon the former surface of the ground, which is composed of yellowish-brown lapilli beds, without forming a new mound around the crater.

At the end of July, the crater contained three feeble fumaroles. Three months later, they were still sending out small quantities of steam.

The craters just mentioned are all that were formed by the eruption on the subaerial part of the flank of the mountain. In addition to these, however, several craters were formed by the eruption on the floor of the bay of Akabakkyô, which may also be regarded as parasitic vents on the submarine extension of the same flank of the mountain. They are:

7. Crater F. According to accounts by eyewitnesses, an eruption occurred from a vent, denoted as crater *F*, in the innermost part of the former bay of Akabakkyô, and near the base of the former sea-cliff of Akabakkyô-hana (or Garaisino-hana). Although this vent, which has been buried beneath later ejecta from neighbouring vents (Hyôtan-yama craters *G* and *H*), does not present the form of a crater, its western inside wall is believed to have been the curved cliff newly cut in the former sea-cliff of Akabakkyô-hana. Thus, the cliff, which is in places both fissured and curved, forming a precipice with a talus conoid of fallen blocks at its base, runs from Akabakkyô-hana northwestward near to the mouth of the boundary valley of Kamituki and Tubota, surrounding the western side of the buried crater *F*, whereas formerly it was a sea-cliff facing the bay of Akabakkyô. At the end of July, vapor-clouds were issuing vigorously from numerous fissures on the ground of the buried crater *F* as well from fissures in the cliff, while at the end of October, vapor could be seen only in a few fumaroles at the base of the cliff.

At the above-mentioned cliff at Akabakkyô-hana are exposed beds of old ejecta which, from their structure, are regarded as products of a near-by crater that was probably situated in the former bay of Akabakkyô and near where the buried crater *F* is supposed to lie at present. The beds, which are composed of reddish-brown lapilli, bombs, and lava-blocks, are intercalated in the middle horizon of the cliff by a sheet of lava, about 3 m thick, dipping about 15°NW. The fragmentary ejecta are petrographically identical with the lava, both being an augite-olivine-basalt, containing large phenocrysts of anorthite more than 1 cm in diameter. Before the late eruption, the same lava was exposed on the northern shore of the former bay of Akabakkyô, forming

a costal platform, about 15m above the sea, on which stood the fishing village of Simasita. At present most of it is buried beneath the new Akabakkyô lava-flow, although it is still exposed in a small area in the southern part of the former shore of Sitori.

Although the new ejecta from crater *F* cannot be recognized in the vicinity of the crater, owing to the latter being covered with ejecta from neighbouring vents, there is no doubt that they are fragmentary ejecta of an almost aphanitic lava. Thus the almost aphanitic bombs, which are scattered on the flat ground of Sitori, and among which those of more than 5m in diameter are met with, must have been thrown out of crater *F*, seeing that the ground upon which they fell are bored in such a way that they show that the tracks of their flight were in the direction of the crater.

Crater *F* lies almost on the northeastern extension of a line connecting craterlets *A*, *B*, and *B'*, and which runs nearly along the boundary valley between Kamituki and Tubota. Judging from the accounts of eyewitnesses, in addition to *F*, there were probably two other vents active in the bay of Akabakkyô and on an extension of the same line, further northeast of *F*, although these vents cannot be found now.

8. New cones G and H (*Hyôtan-yama*). The submarine eruption that occurred at two places in the central part of the bay of Akabakkyô resulted in the formation of two new cones, *G* and *H*, which lie side by side on the northeastern extension of a line passing through craters *D* and *E*, and which have grown and joined into a mound named Hyôtan-yama, because its side view resembles a gourd.

The southwestern half of Hyôtan-yama is a flat cone, about 70 m above the sea, sloping 10～20° on all sides, except on the eastern side where it joins the western side of the other half of the mound. Thus the western slope of the cone extends to the former sea-cliff on the southern side of Akabakkyô-hana, where it joins the mainland of Miyake-sima. The base of the northern slope continues to the new lava-platform that occupies the northern part of the former bay of Akabakkyô; while the southern slope ends abruptly downward with a scarp, about 10 m high, which faces a new coastal flat that formed in the southern part of the former bay of Akabakkyô.

On the summit of the western cone, there is an oval crater *G*, the longer (EW) and the shorter (NS) axes of which are about 100 m and 80 m respectively. The upper rim of the crater gradually rises northward from its lowest point, about 50 m above the sea, on the southern side to its highest point on the northern side, the summit of the cone. The crater-bottom, which has an average diameter of about

20 m and lies about 50 m below the highest northern crater-rim, is covered with detritus that fell from the surrounding walls. The northern crater-wall has several vertical fissures, the larger ones of which form two vertical notches, about 5m wide and 15m deep, in the upper part of the wall.

The eastern half of Hyôtan-yama is occupied by another cone (eastern cone), which is both lower and smaller than the western cone, the two being joined together without forming any notable saddle or valley between them. Thus the eastern cone, which is about 40m above the sea, and whose summit lies about 200m ENE of the western cone, is joined to the latter by a ridge that runs ENE and gently descends in the same direction.

The eastern cone has a shallow, dish-shaped crater *H*, about 50 m in diameter, on the southern side of its summit. The bottom of the crater, which lies about 20 m below the summit of the cone, is flat ground, about 20 m across, covered with fragmentary ejecta (sand, lapilli, and bombs). The northern crater-wall is the highest, having a slope of about 25°, while the southern wall rises only a few meters from the crater-bottom. Thus the outer rim of the crater slopes steeply southward from the highest point on the northern side (top of the cone) to the lowest point, about 20 m above the sea, on the southern side.

The northern flank of the eastern cone extends with a slope of about 25° from the summit, near the upper rim of the northern wall of the dish-shaped crater, to the base, to which latter it is connected with a low, bomb-covered ground lying between Hyôtan-yama and the new lava-platform of Akabakkyô. The southern flank, which is but poorly developed, continues southward with a slope of less than 10° for a distance of about 50m from the southern crater-rim, ending abruptly in a new sea-cliff, about 5 m high above sea level. The extensively developed eastern and northeastern flanks, which were still intact immediately after the eruption, gradually narrowed later, mainly owing to the erosive action of the sea until, at the end of October, as will be described in detail presently, the eastern half of the cone was found completely destroyed. Thus, at the end of July, these flanks showed a regular conical surface with a slope of about 20°, extending from the crater-rim downward to the foot, where they were fringed with a newly-formed sand-beach.

The conical part of Hyôtan-yama above the sea are composed of fragmentary ejecta (scoriaceous lapilli, bombs, and lava-blocks) containing large megascopic phenocrysts of anorthite, although they are underlain by a lava-flow containing the same phenocrysts. When the eastern

cone had been greatly worn down by the sea, a part of the lava-flow became exposed from beneath the overlying ejecta for the first time.

For several weeks following the eruption, the whole ground of Hyôtan-yama was so hot as to be almost unpassable, while at night the glow from the ejecta on the mound were visible quite a distance, so that although on July 24, the writer landed by a boat on the north-eastern shore of the eastern cone, he had to abandon all hopes of ascending the mound on account of the heat and gases that charged every foot of ground. White vapor-clouds were issuing violently from fissures on the outer slopes near the crater of the western cone. Steam was also rising from the shore of the eastern cone, where the sea-water in contact with the hot ejecta had been heated locally to a temperature of as much as 60°C, killing a number of fish.

Three months later, at the end of October, the ground of Hyôtan-yama had cooled down to such an extent as to be freely passable, although some of the fissures near the summit were glowing inside and sending out hot gases. White vapors were issuing vigorously from fissures running ENE on the southern slope of the mound. So far as the summit of the western cone was then concerned, the mound had become a few meters lower than as observed in July.

9. *Submarine crater.* According to Uematu of Tubota, a submarine eruption occurred in the sea, east of Hyôtan-yama, in the direction N 20° E, as observed from Miike-hama. If his observation was fairly accurate, the crater whence the eruption occurred must have been situated in the sea, a few hundreds of meter off the eastern shore of Hyôtan-yama, almost on the eastern extension of the line connecting craters *D*, *E*, *G*, and *H*.

The above-mentioned craters, 1 to 9, with a total of more than twenty vents, were formed by the eruption almost simultaneously or in rapid succession within a few hours beginning at about 7:30pm of July 12, 1940. Judging from the distribution of the ejecta, and also from the accounts of eyewitnesses, these craters must have erupted in the following order: B'_6 (and D ?) → (C, A, B, and $B'_{1\sim5}$) → (E and F) → (G, H, and the submarine crater No. 9), although the exact order in which they began or stopped activity can never be known. Roughly speaking, the eruption in craters $A\sim E$ on the mountain slope slightly preceded those from craters $F\sim H$ in the bay of Akabakkyô, both in beginning and ending, so that although the eruption of the former ended practically in the morning of July 13, that of the latter continued for several hours during the afternoon of the same day. The Hyôtan-yama craters (G and H) were no doubt the last to cease activity, seeing that

the ejecta from these craters overlie those from the remaining craters.

New lava-platform.

A lava-flow which, after descending the boundary valley of Kamituki and Tubota, poured into the northern part of Akabakkyô bay, formed a new platform which filled that part of the bay, covering also the old lava-platform of Simasita on the northern shore of the same bay. This new lava-platform occupies a rectangular area about 800 m long and 300 m wide in the EW and NS directions respectively. Although the surface of the platform is rough with small indentations peculiar to the surface of block lava, it forms as a whole a flat ground dropping imperceptibly eastward from a height of about 20 m above the sea in the western part to that of a few meters above the sea near its eastern margin. The northern margin in the western part of the platform forms a scarp about 5 m in height above the old ground, running east, while the southern margin of the platform is separated from the northern foot of Hyôtan-yama by a fissure-like channel, about 3 m both in width and depth, running east in a winding course on the boundary between them. At the end of July, the northeastern and eastern margins of the platform bordered the sea, although, as will be described in detail presently, they were fringed soon afterward with sand-beaches.

For several days following the eruption, the lava of the platform, which was moving very slowly, locally at least, in the direction of flow, was still red hot inside, as seen from crevices in the lava. During these days, the whole ground of the platform was so hot as to be hardly passable, discharging steam and other gases. Thus hot gases were issuing everywhere from the ground; steam was rising vigorously on the northeastern and eastern margins of the platform, where the lava came in contact with the sea; while smoke with the odour of burning trees rose from the northern part of the platform, where the lava buried every house in the village of Simasita. Three months later, at the end of October, the ground of the platform had cooled down sufficiently to permit passage over it, although local high temperatures (80°～125°C) were observed at several places on the ground, where fumarolic activity was still going on. Steam was still rising from the eastern margin of the platform, although a sand-beach had walled off the latter from the sea.

Fissures.

On both sides of the boundary valley between Kamituki and Tubota, there are numerous fissures in the inside walls as well as on the crests

outside, running nearly parallel to the course of the valley. On the flat ground of the crests, the fissures often form trench-like depressions, a few meters in depth and width, while on the steep inner slopes of the valley, they form step-slips falling toward the valley-floor, causing occasional avalanches.

There are also numerous fissures on the ground of the newly-formed cones *A*, *B*, *D*, *G*, and *H*. Cones *G* and *H* of Hyôtan-yama have many fissures, of which those around the craters on the cones are mostly radial and concentric. The northwestern slope of cone *G* is crowded, particularly, with large fissures that run ENE, along which the ground of the slope slips down a step toward the northern foot of the cone. The bomb-covered, low ground adjoining the northern foot of Hyôtan-yama is also fissured, mostly in two directions, northwest to southeast and west to east.

Although most of the above-mentioned fissures were already present immediately after the eruption, they were seen at the end of October to have increased in number as well as in size. The majority of these fissures, which appear to have been confined to deposits of new ejecta without extending deeply into the underlying old ground, may be merely superficial as the result of settling and contraction of the deposits during cooling.

Besides these superficial fissures, there are two fissure-lines suggested by the linear arrangement of the newly-formed craters. One of these lines is the NE∼SW line obtained by joining craters *A*, *B*, and *B′*, and which may be regarded as a radial fissure-line extending the whole length of the northeastern slope of the volcano from the snmmit of Oyama downward to its foot near Akabakkyô. Thus the southwestern extension of the line reaches to the summit of Oyama, passing through an old parasitic crater near the northeastern rim of the caldera (Hayono-tairo); while the line extends from rift-crater *B′* northeastward to the site of crater *F* in the former bay of Akabakkyô, almost

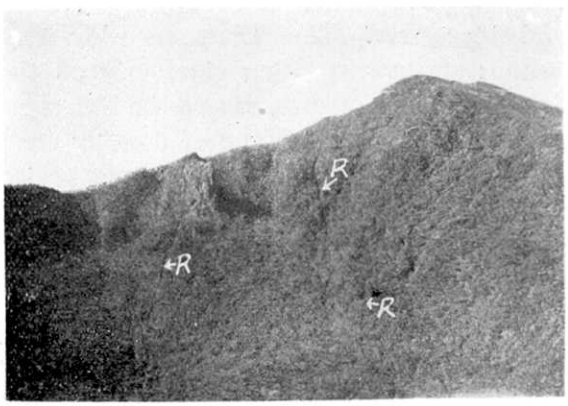

Fig. 54. New fissures (*R*) extending vertically down the inside SW wall of Suo-ana, an old parasitic crater near the summit of the NE somma.

following the lower course of the boundary valley between Kamituki and Tubota. The other fissure is an ENE~WSW line that connects craters *D*, *E*, *G*, and *H*. The western extension of this line which, however, is not in the direction of the summit of Oyama, appears to stretch to the somma, intersecting the above-mentioned line at crater *B*. Thus on the crest near the summit of the somma and in the western inside wall of Suo-ana, an old parasitic crater adjoining the east side of that summit, there are several new fissures lying on or near the western extension of this line (Fig. 54).

These two fissure-lines may be regarded as representing eruption-fissures that extend deep down from near the surface to the heart of the volcano, serving as an outlet for the underlying magma. According to a re-triangulation carried out immediately after the eruption by the Land Survey Department of the Imperial Army, the triangular points, Taka-yama (No. 9) near Akabakkyô and Okura-yama (No. 8) near Miike-hama, showed a northward displacement of 1·31 m and a southward displacement of 1·64 m respectively as compared with their former positions from the survey of 1912, suggesting a north-south dilatation of about 3 m of the land between them. These displacement may be well understood by assuming that the magma beneath the volcano intruded in the form of a dike along the eruption-fissures at the time of the late activity, and that the ground on both sides of the fissures was pushed aside by the intruded mass.

Change of coast-line.

The coast-line between Anô-saki and Satadô-saki shows a great change as the combined results of the formation of a new land reclaimed from the bay of Akabakkyô with the ejecta at the time of the late eruption and the marine action at work on the new land during subsequent days. Fig. 55 shows the coast-lines both before and after the eruption.

As will be seen from the figure, before the eruption, the coast-line between Anô-saki (*A*) and Satadô-saki (*G*) was deeply indented westward in the middle part from Mahana (*B*) to Yoridai-hana (*F*), bordering the bay of Akabakkyô, thus forming the best harbour in the island. The northern part of the coast (Sitori) between *A* and *B* was a gravel-beach dotted with exposures of old lava-flows, while its southern part near *B* was a vertical sea-cliff, 5~10 m above sea level, exposing a massive lava of augite-olivine-basalt containing large phenocrysts of anorthite. A sea-cliff of the same lava developed around the cape of *B* as far as the mouth of the boundary valley between Kamituki and Tubota (*C*). On this cliffy coast stood the fishing village

of Simasita. On the south side of *C*, there was a higher sea-cliff that rose gradually southward to the head of the cape of Akabakkyô-hana (*D*), where it attained a height of about 50 m. As already mentioned, this cliff was practically demolished by the eruption that lately occurred from crater *F* near its base. The coast between *D* and *G* was a sea-cliff, 20～30 m high above the sea, continuing for the whole length, the mouth of the Yomogiga-sawa (*E*) and that of the Yoridai-sawa (*F*) excepted, and exposing several superposed lava sheets. Being surrounded on its western side by sea-cliffs between *B* and *F*, Akabakkyô bay had an average depth of about 10 m.

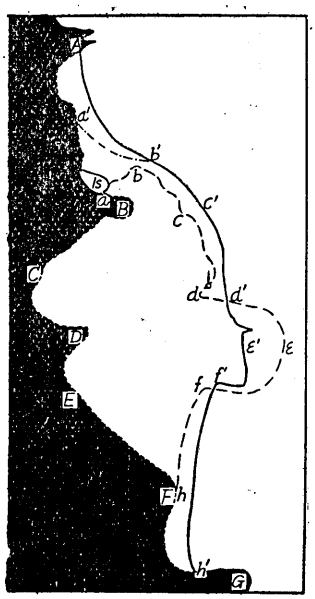

Fig. 55.

Immediately after the eruption, it was found that the bay, as a result of the activity, had been completely covered with new land, namely the Akabakkyô lava-platform and the Hyôtan-yama cones, and that the land had formed a new coast as shown by the line *a*–*c*–*e*–*h* in Fig. 55. At that time, coasts *A*–*a* and *h*–*G* were virtually as before. The new coast-line from *a* to *c*, which skirts the north-eastern margin of the Akabakkyô lava-platform, was greatly indented with small inlets that were the submerged ends of small depressions on the lava-flows of which the platform was formed. The farthest front of the lava-flows must have stopped on the sea-floor not far from the coast, seeing that, according to a provisional sounding executed by the officers of Kamituki, the sea near the shore between *a* and *c* had, as before, an average depth of about 10 m. The coast-line from *c* to *d*, which was the eastern margin of the bomb-covered, low ground between the Akabakkyô lava-platform and Hyôtan-yama cones, was also greatly indented with small inlets, although, a week after the eruption, it was seen already fringed locally by a narrow beach of sandy material brought from the sea by the incoming waves. The northeastern coast *d*–*e* of Hyôtan-yama was fringed with a long sand-beach, showing a smooth shore-line, while its south eastern coast *e*–*f* had already been cut with a sea-cliff, about 3～5 m above the sea. The coast between *f* and *h* was a sand-beach, fringing the eastern margin of the bomb-covered flat that had formed between the southern foot of Hyôtan-yama and the former sea-cliff *E*–*F*.

In the course of a few months following the eruption, the action

of the waves had completely changed the coast-line between *A* and *G*. In the middle of August, according to Honda[2] and his collaborators, the sand-beach between *f* and *h* had increased in width, and at the same time extended from *h* southward to the sea-cliff near *h'* on the northern side of Satado-saki. According to Miyamura[3], about the middle of the month following, it was found that much of the eastern part of Hyôtan-yama had been destroyed, and that the coast between *a* and *d* had been fringed with a continuous sand-beach extending from *a'* to *d'*. The inner part of the inlet (*a'–a–b*) of Sitori remained as a small lake (1s), about 150 m long and 50 m wide, embanked on its eastern side by a broad sand bar extending from *b'* to *a'*.

At the end of October, when the writer made his second visit to the island, the destruction of the eastern part of Hyôtan-yama and the growth of the sand-beaches on the neighbouring coast had advanced further, resulting in the formation of a coast-line, shown by the line *A–c'–e'–f'–h'*. Thus the eastern half of the eastern cone of Hyôtan-yama completely disappeared; a vertical sea-cliff was formed near the eastern crater-rim of the cone, giving rise to a north-south section that afforded a clear view of the internal structure of the cone; the sand-beach between *a'* and *b'* broadened and extended northward as far as Ano-saki, while the sand-beach between *f'* and *h'* increased in width as well as in the thickness of the deposit.

The newly-formed sea-cliff on the eastern side of Hyôtan-yama exposes massive lava, black scoria, and reddish-brown scoria, accumulating in succession from the base of the cliff upward. The lava, which is an olivine-basalt, sporadically containing large phenocrysts of anorthite, forms an almost horizontal bed, the visible part of which above the sea is about 3 m thick. The upper part near the surface of the lava bed is more or less scoriaceous, and contiguous (without any distinct boundary) to an agglutinate-like mass, 2～3 m thick, consisting of black scoria and bombs. The latter is overlain by an almost massive bed of reddish-brown scoria, the maximum thickness of which in the middle part of the cliff is about 20 m. Above this scoria-bed is a black lapilli-bed, less than 50 cm thick, sporadically containing bombs. Immediately after the eruption, this lapilli-bed was a continuous surface mantle of the eastern cone of Hyôtan-yama, although later it was covered by a thin bed of reddish-brown, scoriaceous sand that was scattered over the cone by the minor explosions that occurred several times on the eastern shore of Hyôtan-yama. The fragmentary ejecta exposed on the sea-cliff are, like

2) H. Honda, *Kensin Ziho*, **11** (1940), 277.
3) Oral information.

the underlying massive lava, exclusively an olivine-basalt carrying large phenocrysts of anorthite.

The formation of the new sand-beaches, *A–d'* and *f'–h'*, is supposed by Honda and his collaborators to indicate a local upheaval of that part of the island, accompanied by local subsidence of the opposite coast near Akò. But, according to a levelling made after the eruption by the Land Survey Department of the Imperial Army, the island everywhere subsided more or less relative to the sea, excepting a small area near the coast around Satado-saki where a negligible upheaval of about 2 cm was measured. With this in view, and judging from the above-mentioned fact that the sand-beaches extended gradually from near the coast of Hyôtan-yama to a great distance in the course of a few months following the eruption, there is no doubt that they were virtually formed by the action of the waves. Thus, by wave action, the seaward side of Hyôtan-yama was washed away, its material distributed over the neighbouring sea bottom, and the material transported again, together with some ejecta that were scattered over the sea bottom by the eruption of July 12~13, to accumulate on the adjoining coasts, resulting in the formation of the sand-beaches. The last-named consist of more or less water-worn fragments of new lava, isolated crystals of anorthite and olivine, and some accessory pumice. The lava fragments are almost exclusively, like the ejecta of Hyôtan-yama, an olivine-basalt carrying large phenocrysts of anorthite, although fragments of an aphanitic basalt, similar to the plateau-forming lava of Akabakkyô, are accumulated in a small area of the sand-beach that adjoins the eastern side of the new lake of Sitori. The isolated crystals of anorthite and olivine are not the primary ejecta (crystal-bombs or crystal-lapilli), but are regarded as pieces detached by wave action from lava fragments containing phenocrysts of these minerals.

THE ZONE OF SUMMIT ERUPTION.

As the result of the summit eruption of the central cone Oyama which, following the flank eruption of the somma on July 12~13, lasted for 24 days from July 13 to August 5, the configuration of the area in and about the old craters on the central cone markedly changed. Sketch-map, Fig. 56, shows the feature of the top of the central cone when the writer visited it at the end of October, 1940.

New central cone. The most notable topographical change caused by the summit eruption was the formation of a new central cone extending over the northwestern half of the Oana crater and the whole of the upper (western) crater on the old central cone. The new central

cone has a composite structure consisting of three parts, the first, the second, and the third cones.

The first cone. This cone, which had formed in an early phase of the summit eruption, was already seen at the time of our visit to the scene of the eruption on July 25, when, as viewed from the north-western part of the Hayono-tairo atrio, it appeared like a low homate formed around the second centre of activity, which was situated near the boundary between the Oana crater and the upper crater. After that, however, it was buried for the most part underneath the second and the third cones that were formed in the later phase of the summit eruption. Thus at present, only a small part of the first cone remains uncovered. forming a part of the southeastern side of the new composite cone.

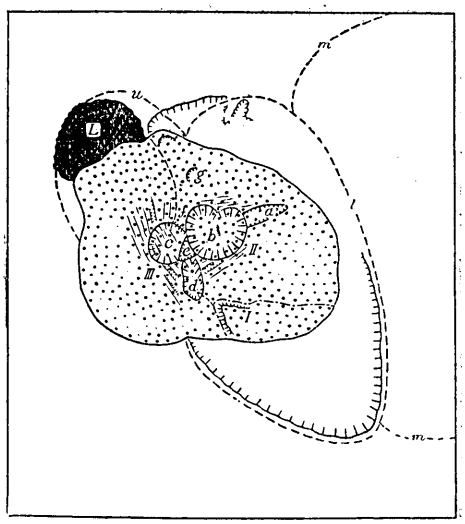

Fig. 56. Sketch-map showing the summit of Oyama.

I-II-III: New composite central cone. *a*~*g*: Craters on the new central cone. *L*: New lava-coulee. *l*: Upper rim of Oana, the deepest crater on the old central cone. *m*: Upper rim of the eastern crater. *u*: Upper rim of the western (upper) crater.

Since the top of the remain of the first cone protrudes several meters from the slopes of the second and the third cones, the northern and western sides of the former adjoin the cliffs to the southern slope of the second cone and the southeastern slope of the third cone respectively. The southeastern side of the protrusion, which represents the original conical surface of the first cone, slopes about 35° southeast, widening from the top downward to the lowest part of the bottom of Oana, which lies about 60 m below the top. The top of the cone was dotted with feeble fumaroles at the time of the writer's visit.

The second cone. Although this cone, which rests on the first, occupying the greater part of the eastern half of the composite cone, is believed to have been formed by materials ejected largely from the second centre of activity, a slight change either in the centre of activity or in the direction of the ejecta must have occurred when the activity shifted from the first cone to the second, seeing that structurally they are slightly unconformable with each other.

Since the second cone, which has a diameter of about 300m at the base, is slightly lower than the northern and southern walls of the Oana crater, its height is about 75 m above the lowest part of the pit of the bottom of Oana, or about 60m above the flat ground in the north-western part of the Hayono-tairo atrio. Its outer slopes show a conical surface having a slope of about 30° on all sides except the west, where the cone joins the eastern side of the third cone, so that, although the southern slope of the cone is only imperfectly developed by protrusion of the first cone, the eastern and northern slopes are well developed, facing the inside eastern and northern walls of the Oana crater respectively.

The third cone. This cone, the result of materials ejected largely from the third centre of activity, forms the highest part of the composite cone, occupying the western half of the latter, and lying on the southeastern part of the old upper crater. It has a radius of about 250m at the base, its height being about 90m above the north-western atrio, or about 110 m above the lowest part of the crater-bottom of Oana, while its top is about 10m lower than the head of the southern crater-wall of Oana.

The outer slopes of the third cone are regularly developed on all sides except the east, where the cone joins the western side of the second cone. The northwestern flank of the cone descends with a slope of about 35° from the top northwestward to the ground of a new lava-coulee which, as will be explained presently, fills up the northwestern part of the upper crater. The western and southern flanks of the cone, which form a slope of about 20°, stretch over the southwestern rim of the upper crater downward to the southwestern slope of the old central cone. The southeastern flank of the cone, which covers a part of the western crater-wall of Oana, descends abruptly with a slope of about 50° from the top to the base where it is contiguous to the western side of the remant of the first cone.

Craters on the new central cone. The new central cone has seven craters, as shown in Fig. 56, letters *a*, *b*.....and *g*. Of these, *a*, *b*, and *g* lie on the second cone, *c* on the third cone, and *d*, *e*, and *f* on the boundary of the two cones.

a. Crater a, which is a spoon-shaped hollow on the northeastern flank of the second cone, extends with a width of about 30m from the top downward near to the base of the cone, forming a channel, about 5 m deep, in the ground of the cone surface. From its position, it is inferred that this crater corresponds to the first centre of activity, and consequently that, although the eruption at this point was not vigorous enough to form a conical mound, it lasted for some time after the vent

was buried beneath the materials (the second cone) ejected from a neighbouring vent (the second centre of activity), resulting in the formation of the crater in question. At the beginning of the summit eruption, as already mentioned, the first centre of activity was the only active vent that continually sent up a spiral column of ash-cloud, accompanied with fierce rumblings; while on July 25, when the eruption had culminated by ejecting bombs from the second and third centres of activity, it was sending up continually but very gently, only a small quantity of light-grayish ash-cloud. At the end of October, white vapors were rising from the ground in and about crater *a*, the successor to the first centre of activity.

b. Crater b, which is the largest of the craters on the new central cone, lying on the second cone, is a circular bowl, about 100 m in diameter, surrounded by almost perpendicular walls, exposing an unstratified pile of reddish-brown ejecta (volcanic sand, lapilli, bombs, and lava-blocks). The crater-bottom, which is also covered with these ejecta, is about 100 deep in its western part, and about 70 m deep in its eastern part.

Judging from its location, this crater corresponds to the second centre of activity. Thus, as viewed from the northwestern part of Hayono-tairo, the former is exactly in the direction of the latter which, on July 25, was seen from the same point sending up, periodically, a black ash-cloud densely charged with non-incandescent bombs. At the end of October, white vapors were issuing from many fissures on the ground outside the crater-bowl, the ejecta exposed in some of the fissures being still red-hot, although there was neither fumarole nor solfatara on the bottom of the crater.

c. Crater c, which represents the main vent of the third cone, lying on the eastern side of the highest point of the cone, is a circular dish-shaped hollow, about 80 m across. The crater-rim is highest on the western side, descending gradually eastwards. The crater-walls, that slope about 25° inward, are thus about 35 m and 20 m in height on the western side, and the northern and southern sides respectively, while the eastern crater-wall is almost non-existent. The eastern margin of of the crater-bottom, which is flat ground, about 30 m across, covered with sand, lapilli, and bombs, is delimited by the western rim of the adjoining deeper crater e.

This crater is succeeded to the third centre of activity which, as viewed on July 25 from the northwestern part of Hayono-tairo, was erupting in rapid succession with lightning-like flashes, accompanied by ejection of incandescent bombs. At the end of October, white vapors were issuing from many fissures on the ground in and about the crater.

d. *Crater d* lies about 25m northwest of the top of the first cone and on a level several meters higher than the latter, on the boundary between the southwestern flank of the second cone and the southeastern flank of the third cone. It is an oval hollow about 50m long and 30m wide, becoming narrower toward the bottom, which has a diameter of about 5 m. The eastern and western crater-walls, sloping about 50° inward, cut deeply the southwestern flank of the second cone and the southeastern flank of the third cone respectively. The northern crater-wall is a narrow ridge, about 20 m high, which separates this crater from the adjoining crater *e*. The southern crater-wall forms a low, narrow ridge, sloping steeply toward the crater-bottom on one side and gently toward the top of the first cone on the other. At the end of October, neither fumarole nor solfatara was found on the crater-bottom, which was covered with detritus from the surrounding walls.

e. *Crater e*, which is a triangular-shaped hollow, about 20m across and 10 m deep, occupying the interspace between *b*, *c*, and *d*, is separated by thin walls, probably less than 5 m thick, from *b* on the east as well as from *d* on the south. The western side of the crater forms a cliff falling almost perpendicularly from the eastern margin of the crater-bottom of *c*. At the end of October the crater contained several vents discharging white vapors.

f. *Crater f*, which is a shallow, dish-shaped hollow adjoining the northwestern and northeastern rims of *b* and *c* respectively, is separated from *c* by a low saddle, sloping very gently on both sides toward the crater-bottoms, while the former is cut on the eastern side by the rim of the inside northwestern wall of *c*. The crater-bottom is covered with lapilli and bombs. At the end of October, it was studded with numerous small vents sending up white vapors.

g. *Crater g*, a circular dish-shaped hollow, about 20m across and 5m deep, lies half-way down the northern flank of the second cone.

The foregoing seven craters are *b*, *c*, *d*, *e*, *a*, *f*, and *g* diminishing in size in the order given, while *a*, *b*, *g*, *d*, *e*, *f*, and *c* increase in the order of height of crater-bottom, as measured from the lowest part of the crater-bottom of Oana. Of these craters, *b* and *c*, which are the main vents of the new central cone, are arranged together with *a* on a ENE–WSW line, while the others, which may be regarded as subsidiary, rather epigenetic vents participating more or less in modifying the original form of the cone, are arranged on a NNW–SSE line running nearly along the boundary of the second and third cones. These two crater-lines intersect nearly at right angle in the vicinity of crater *e*.

Besides the foregoing craters, there is a small, shallow depression

on the northern foot of the second cone, and nearly on the northern extension of the NNW–SSE crater-line above referred to, which may be regarded as the remnant of a new crater, although most of it is buried in the talus of the cone.

New lava coulee. On the northwestern foot of the new central cone is a new lava coulee, about 130 m in length from northeast to southwest and about 85 m in maximum width from northwest to southeast, extending in a semi-circular area, approximately $2 \times 10^4 m^2$. The lava coulee is circumscribed by the rim of the old upper crater on all sides except on its southeast, where it is buried beneath the new central cone. Thus the northeastern and northern margins of the lava coulee come in contact with the inside northeastern and northern walls of the crater, while the western margin bulges out only a few meters westward over the rim of the western wall of the crater.

The surface of the lava coulee is generally flat with a veneer of fragmentary ejecta, which is less than 10 cm thick in the northwestern part, reaching an extreme thickness probably of more than 1 m in the southeastern part near the foot of the central cone. The northwestern margin of the lava coulee forms a cliff about 3~5 m high, exposing the lava which, although broken to angular blocks on the surface of the exposures we meet with a more or less ropy, fluidal structure, besides parallel scratches aligned in the direction of the flow.

New fissures. The new central cone is cut by numerous fissures as indicated by trench-like depressions, stepped slides, and by lines of fumaroles. Thus, in and around crater *c* on the third cone are numerous parallel fissures running in a NNW–SSE direction, while outside the northern and southern walls of crater *b* on the second cone are fissures running parallel in a ENE–WSW direction. These two fissure systems, NNE–SSE and ENE–WSW, which are nearly parallel to the crater-lines, *d–e–f–g* and *a–b–c*, respectively, indicate the lines of structural weakness not only of the new central cone but possibly also of the underlying ground. One of the fissures on the eastern side of the top of the third cone forms a trench-like depression, about 15 m wide and 5 m deep, cutting the southwestern wall of crater *c* in a NNW–SSE direction.

The southern inside wall of the Oana crater fissured and collapsed along its upper margin, probably owing to shocks received during the summit eruption, resulting in an almost perpendicular cliff with a talus conoid at the base, whereas formerly it was a slope clothed with vegetation. In the newly-formed cliff of the wall are exposed two sheets of lava, of which the upper one exposed at the brink of the cliff is an augite-olivine-basalt.

The western half of the northern inside wall of the Oana crater also fissured and broke down by explosions that probably occurred near the base of the wall early on July 19 and 20, so that the wall now forms an almost perpendicular cliff, about 30 m high, whereas formerly it was a slope of about 50°, clothed with vegetation. In the upper part of the cliff is exposed a sheet of massive lava (augite-olivine-basalt), about 1 m thick, intercalated in a thick bed of reddish-brown scoria. Under this bed, in the lower part of the cliff is exposed another lava (augite-olivine-basalt), more than 5 m thick which, near the surface of the cliff is white, probably due to decomposition by solfataric action. This rock may be the source of the whitish sand and lapilli that fell in quantity in the vicinity of Akabakkyô during the summit eruption of July 19 and 20.

The inside eastern wall of the Oana crater was not much altered by the summit eruption, remaining as before, a perpendicular lava-cliff, although the lower part of the cliff was deeply buried in new ejecta.

IV. Distribution and Volume of the Solid Ejecta.

THE ZONE OF FLANK ERUPTION.

The solid materials ejected by the flank eruption are volcanic ash, sand, lapilli, bombs, lava-blocks, and lava-flows. The distribution of these ejecta on the island will be seen from Fig. 5.

Volcanic ash. The volcanic ash are distributed in a fan-shaped area, widening northeastward from the uppermost crater A. Thus the northern limit of the ash-covered area is represented by a straight line connecting A and Hodai, and the southern limit by another straight line connecting A and the northern corner of Miike-hama. Very little ash accumulated in this area, their deposit being less than 1 m thick even in the central part near the boundary valley between Kamituki and Tubota. Although ash are accumulated about 5 cm deep in the southern part near Miike-hama, most of it is ejecta from the summit of the volcano.

Volcanic sand, lapilli, bombs, and lava-blocks. These cover a fan-shaped area, about 2 km long and 1 km wide, extending from the uppermost crater A northeastward to the former bay of Akabakkyô, besides having accumulated in the form of new parasitic cones about craters A, B, D, G, and H. Their thickest deposit is a zone, about 400 m wide, extending from crater A northeast toward Akabakkyô. The deposit, which reaches to about 3～5 m in thickness in this zone, thins out rapidly on both sides, while near the margin of the fan-shaped area, the ejecta

lie only sparsely on the surface of the old ground.

The quantities of volcanic sand and lapilli are, generally speaking, relatively small. Thus, so far as the visible parts are concerned, the above-mentioned fan-shaped area is covered for the most part with coarser ejecta—scoria, bombs, and lava-blocks—which usually exceed 5 cm in diameter. The only part where volcanic sand and lapilli are abundantly found was a small area, already washed away by the waves, in the eastern half of Hyôtan-yama. Although some volcanic sand and fine lapilli cover the gentle slope adjoining the southern side of the boundary valley between Kamituki and Tubota, most of them are materials that were ejected by the summit eruption.

The volcanic bombs have accumulated thickly on the ground around the craters. Judging from the distribution of these bombs, their ejection from a crater took place mainly at a later stage of the eruption of the crater. For example, Hyôtan-yama is thickly covered with volcanic bombs, while, as observed in the sea-cliff on its eastern side, its inner part is largely composed of scoriaceous lapilli and blocks.

The diameter of the volcanic bombs mostly exceed 10 cm, the largest one so far found being about 10 m, while those of less than 5 cm are rare. The bombs are divided into two kinds according to their internal appearance, compact bombs having relatively smooth surfaces and porous bombs having uneven surfaces. In their fall upon the ground, the compact bombs are either scarcely deformed or are broken into several angular fragments, whereas the porous bombs are either more or less flattend or are partly imbedded in the ground, their surface conformations indicating that they must have been plastic when they reached the ground. The ground on which the large-sized bombs are scattered is dotted in places with conical hollows formed by their fall. These hollows are usually several times larger than the bombs found in them.

Along with the volcanic bombs, irregular-shaped lava-blocks are accumulated on the ground around the new craters, particularly so on the mountain slope adjoining the northern side of the B' rift-crater, where huge lava-blocks, about 10 m in diameter, are frequently met with.

The above-mentioned fragmentary ejecta are divided petrographically into two kinds, porphyritic olivine-basalt containing large phenocrysts of anorthite, and almost-aphanitic basaltic-andesite. The ejecta of porphyritic basalt, which were thrown out exclusively from craters G and H, are distributed in a circular area, about 600 m in radius, extending northward to Sitori and southwestward to Yoridai-sawa, with

Hyôtan-yama as the centre. The ejecta of the almost aphanitic basaltic-andesite, which were projected from all the new craters except G and H, are distributed over the greater part of the fan-shaped area just mentioned, widening out from crater A downward to an extreme width of about 2km. Although the products ejected from the various craters must have accumulated in various areas, each according to the source of ejection, owing to their uniform petrographic characters, they cannot be distinguished the one from the other. The northeastern part of the area that is covered with the almost-aphanitic ejecta falls on that of the porphyritic ejecta. Here, there are not a few instances in which a porphyritic bomb and an aphanitic bomb are piled one on top of the other, in which case the porphyritic bomb always rests on the aphanitic bomb, indicating that the outpouring of the porphyritic ejecta from Hyôtan-yama continued for some time after that of the aphanitic ejecta from a certain neighbouring crater had ceased.

The total volume of the fragmentary ejecta is approximately $85 \times 10^5 m^3$, inclusive of the subaerial part of Hyôtan-yama, which has a volume of about $72 \times 10^5 m^3$. Its greater part must be occupied by coarse scoria, bombs, and lava-blocks, seeing, as already mentioned, that the amount of the finer ejecta (ash and sand) is relatively small. This fact may be a characteristic of the fiank eruption, suggesting that the eruption took place with a relatively week explosive force from the eruption-fissures that opened on the mountain slope as the result of interusion of magma underneath the volcano.

Lava-flows. In the zone of flank eruption are three new lava-flows, the Akabakkyô, the Yoridai-sawa lava-flow, and the Hyôtan-yama lava-flow. These lava-flows are distributed as follows:

The Akabakkyô lava-flow. This flow, which is represented by the Akabakkyô lava-platform already referred to, can be traced from the mouth of the boundary valley between Kamituki and Tubota upstream to the B′ rift-crater, whence the lava is exposed in the northern and southern walls of the crater, while no more of it is found on the A and B cones, which are composed entirely of fragmentary ejecta. Besides, outside of the B′ crater are found a number of huge volcanic bombs and blocks, petrographically similar to the lava, so that it is inferred that the lava erupted from this crater.

Although most of the lava must have flowed directly into the boundary valley, part of it overflowed the southern wall of the crater, with the result that the lava is distributed on the mountain slope adjoining the southern side of the crater, where it forms a blocky lava-field extending about 250 m from WSW to ENE with a maximum width of

about 100 m. At the southeast corner of the field, the lava-flow branches off northeast across a small valley, while at the northeast corner it forms a lava-cascade, about 20 m wide, hanging over a steep southern wall of the boundary valley. The lava-field, which is composed of broken lava with some volcanic bombs and other fragmentary ejecta, is greatly indented with small ridges and furrows, most of them running E–W and N–S. At the end of October, 1940, white vapors were issuing from a number of fumaroles developed in the lava-field, and a small pond, about 20 m in diameter, was found at the southeastern corner of the field where the lava had dammed a small valley.

The lava-flow is scarcely exposed on the bottom of the B′ rift-crater nor on the space of about 600 m of the floor of the boundary valley into which the crater opened, where it is buried beneath the detritus (fragments of volcanic bombs and scoriaceous lapilli) that fell from the side wall (Fig. 57).

The lava-flow is exposed continuously on the floor of the boundary valley from the middle course of it, about 180 m above the sea, downstream to the mouth of the valley, although its margins near the valley walls are covered with detritus that slid down from the walls. Thus, on the southwestern foot of Taka-yama, where the valley floor is about 90m wide, the lava-flow is exposed for a width of about 35 m in the central part of the valley floor, while on the southeastern foot of the same hill, where the valley floor becomes less than 30 m wide, the flow not only covers the valley floor, but is thrown up like a lateral morain outside the valley. From the mouth of the boundary valley eastward, the lava-flow is distributed over an extensive area that covers the northern part of the former bay of Akabakkyô, forming the Akabakkyô

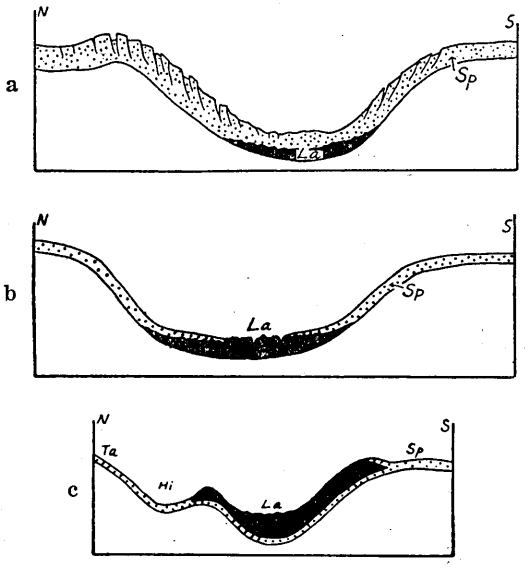

Fig. 57 a, b, c. Diagrammatic cross-sections of the boundary valley between Kamituki and Tubota. a. Upper course. b. Middle course. c. Lower course.

Sp: Volcanic sand, lapilli, and bombs. *La*: Akabakkyô lava. *Ta*: Taka-yama. *Hi*: Hino-ana.

lava-platform already referred to. The village of Simasita is buried completely by the lava, although a very small rocky hill of the village, called Nezumisama, is left uncovered.

Although the lava-flow is represented locally by a conglomeration of angular lava-blocks, it forms on the whole a continuous, massive lava-sheet, except for the surface crust which is broken into blocks. Thus, in the lower course of the boundary valley and on the Akabakkyô lava-platform, where the lava-flow is traversed by contraction-fissures in many directions, massive parts of the flow are exposed in the walls of the fissures. Furthermore, on the Akabakkyô lava-platform, the lava-flow consists locally of two or three massive lava-sheets intercalated by scoriaceous lapilli and blocks, accumulating one on top of the other.

The thickness of the lava-flow on the floor of the boundary valley and in the northwestern part of the Akabakkyô lava-platform is about 3～5 m, while it is about 15 m in the southern part of the platform where, formerly, the bay of Akabakkyô was about 10 m deep. Taking these figures into account, the volume of the lava-flow is approximately $45 \times 10^5 m^3$.

As to the time of outflow and rate of flow of the lava, there is no reliable information. All we have is Z. Asanuma's statement that a refugee (Yamamoto) ran down the mountain slope, seeing the lava-front descending the boundary valley. If this information is correct, it is probable that the lava began to flow out shortly after the start of the flank eruption, and that it descended the boundary valley at the rate of several meters per second.

Seeing that the Akabakkyô lava-platform is dotted with fragmentary ejecta from Hyôtan-yama, the bulk of the former evidently formed some time before the eruption of the latter ceased during the afternoon of July 13. But the lava-flow was moving slowly, locally at least, for several days more. Thus, on the morning of July 13, some of the houses in Simasita were still uncovered, while the next morning, the

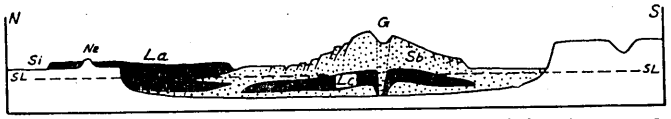

Fig. 58. Diagrammatic section of the new land reclaimed from the bay of Akabakkyô.
La: Akabakkyô lava-platform. *Lc*: Hyôtan-yama lava. *Sb*: Hyôtan-yama ejecta. *G*: crater on the western cone of Hyôtan-yama. *Ne*: Nezumisama. *Si*: Sitori. *SL*: Sea level.

ground adjoining the northern side of the small rocky hill (Nezumisama) in the village was still readily passable, whereas on the morning of July 15, when the writer visited Akabakkyô for the first time, the village had

been completely deluged with the lava-flow, exactly as we see it today Moreover, according to Hagiwara, the lava-flow at the mouth of the boundary valley, on July 19, was moving at the rate of about 3 m a day, and it was nearly five days later that the movement become almost imperceptibie.

The Yoridai-sawa lava-flow. This flow, which came from crater D, poured southwestward into the Yoridai-sawa valley, reaching Kurano-taira, about 1 km distant from the crater, in the lower course of the valley. Being dammed by the lava-flow, a gourd-shaped lake, about 100 m in maximum diameter, was formed on the valley floor adjoining the northern foot of Daihannya-yama. Besides this main flow, a smaller one, which overflowed the northern rim of the crater, descended the adjoining mountain slope eastward for a distance of about 150 m.

At a point about 500 m distant from the crater, the lava-flow in the Yoridai-sawa reaches a maximum width of about 100 m, while at the farthest front, it is only about 5 m wide. At a distance of about 300 m from the crater, where formerly a cliff stood on the valley floor, the lava-flow forms a lava-fall, about 15 m high and 20 m wide. The thickness of the lava-flow is about 5～10 m throughout the whole course of the flow, its volume being approximately $3 \times 10^5 m^3$.

As to the time of outflow of the lava, although no reliable information is available, it may be said that the lava issued some time toward the end of the flank eruption, seeing that it is covered with only a small amount of fragmentary ejecta that was thrown out by the eruption. On July 17, when the writer observed the lava-flow for the first time, its end at Kurano-taira had already grown cold all over the surface except for a few spots where secondary fumaroles were issuing vapors. On the boundaries adjacent to the lava-flow, trees were down, but not burnt, pointing to comparatively low temperature of the lava at the time of flow. So far as the lava-flow in the lower course is concerned, its temperature at the time of eruption might not have been high enough to yield a stiff viscous flow. Thus the lava-flow, which is not traversed by gaping crevices due to thermal contraction, is broken into solid, angular fragments, suggesting in appearance nothing but boulders and debris.

The Hyôtan-yama lava-flow. Although, immediately after the eruption, Hyôtan-yama, from appearances was believed to have been built up with fragmentary ejecta alone, it was found later, when much of the eastern part of the mound was demolished by the action of the waves, that the fragmentary ejecta is underlain by a massive lava-flow, the last-named being exposed in the sea-cliff on the eastern side of

Hyôtan-yama, where it lies almost horizontally, occupying the lower one-tenth of the cliff. On the southeastern coast of the mound, where the sea-cliff is about 3~5 m above sea level, the lava-flow forms almost the whole surface of the cliff, rising gently westward, while at the western end of the cliff, it gradually turns into an agglutinate-like mass of volcanic bombs and scoria. The same lava is also exposed patchwise on the sand-beach that adjoins the northern end of the eastern sea-cliff of Hyôtan-yama.

Judging from its distribution and its disposition as exposed in the sea-cliffs above referred to, the Hyôtan-yama lava-flow is believed to have erupted from crater G at an earlier date, when the crater was still below sea level. Although its bottom is not visible, it is possible that the lava-flow is about 13 m thick, assuming that the lava rests directly on the former bottom of the bay of Akabakkyô. The volume of this lava-flow is approximately $24 \times 10^5 m^3$.

The total volume of ejecta distributed over the zone of flank eruption is approximately $15{\cdot}7 \times 10^6 m^3$, and the entire mass $39{\cdot}2 \times 10^6$ tons, assuming that the average density of the ejecta is 2·5. This mass nearly equals the mass of the ejecta of 1874, while the former corresponds approximately to 1/75 of the whole of the ejecta of Sakura-sima in 1914.

THE ZONE OF SUMMIT ERUPTION.

New fragmentary ejecta. The fragmentary materials ejected by the summit eruption are volcanic ash, sand, lapilli bombs, and lava-blocks. These ejecta not only constitute the new central cone, but are also scattered around the cone.

The new central cone is composed wholly of fragmentary ejecta of various sizes. As to its remnants, the first cone is covered with relatively larger-sized bombs and lava-blocks. The second cone being composed of volcanic sand, lapilli, bombs, and lava-blocks, the sand, lapilli, and small-sized bombs are distributed on the top as well as on the northern slope of the cone, while relatively larger-sized bombs and lava-blocks are accumulated on the eastern and southern slopes. The third cone is also composed of volcanic sand, lapilli, bombs, and lava-blocks.

The new central cone, consisting of the foregoing three parts, has a volume of approximately $3 \times 10^6 m^3$.

Volcanic bombs and lava-blocks are distributed in an oval area measuring about 850 m from NNE to SSW and 650 m from WNW to ESE, with the new central cone as the centre. Thus they lie scattered in the central part of Hayono-tairo as well as on the ground outside the southern rim of the Oana crater. On the northern flank of the old central

cone are found not a few large bombs that reach an extreme diameter of about 3 m. Large bombs and lava-blocks are also found in the south-eastern foot of the new central cone, where they are accumulated possibly more than 10 m deep, together with smaller ejecta.

Volcanic ash, sand, and lapilli are distributed in a fan-shaped area that widens out from the point of eruption on the new central cone ENE to an extreme width of about 3 km. Thus their deposit is thickest in a zone running from the summit ENE toward Akabakkyô, where it reaches several centimeters in thickness, and thins out rapidly on both sides of that zone. Toward the summit, the thickness of the deposited ejecta as well as the sizes of the individual ejecta naturally increase, the volcanic sand and lapilli attaining a thickness of about 50 cm on the northeastern flank of the old central cone and about 1 m on the southern rim of the east crater, while they are accumulated possibly several meters deep on the bottom of the same crater, where formerly were found bombs, and anorthite lapilli of unknown age. A number of small bombs, about 0·5～1·0 cm in diameter, are found on the bottom of the east crater, although neither Pele's hairs nor tears are found. In the later period of the summit eruption, ash fell on the mountain slopes in the directions of Tubota, Ako, and Igaya, according to change of wind, but their deposit on these slopes is negligible in amount, excepting within a distance of about 100 m from the foot of the new central cone, where ash are accumulated several scores of centimeter deep along with sand and lapilli. The total volume of the fragmentary ejecta distributed over the zone of summit eruption is approximately $7 \times 10^4 m^3$, exclusive of the new central cone.

New lava-flow. In the zone of summit eruption, as already mentioned, there is a new lava-flow on the northwestern foot of the new central cone. We have no information regarding the time of eruption and the centre of outflow of the lava, but, from field observations, the lava must have erupted either from the second or the third centre of activity some time between July 25 and 31, before the new central cone had grown into its present size. Consequently, although its bottom is not visible, it is possible that the lava extends for some distance underneath the central cone, with a thickness of possibly more than 5 m. So far as its visible part is concerned, the lava has a volume of $10^5 m^3$ approximately, assuming its average thickness to be 5 m.

V. Damage caused.

Since, in the late eruption of Miyake-sima, it was possible for the

majority of those who lived in Simasita and on the mountain slope near Akabakkyô to escape the moment they saw the beginning of the activity, the casualities were fortunately small, although there was considerable damage to property. The following table, based on investigations made by the Miyake-sima Branch of the Tokyo Prefectural Office, gives the results of the eruption.

	Kamituki	Tubota
People killed (fate unknown)	9	2
People wounded	10	10
Cows killed	12	13
Houses burnt and buried under ejecta	47	20
Farms and forests devastated	$48\times10^4m^2$	$90\times10^4m^2$

(to be continued.)

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27. 昭和 15 年 7 月三宅島の噴火

三宅島噴火の地質學的觀察 (II)

地震研究所 津屋弘達

三宅島火山の今回の活動はその外輪山の北東側山腹と中央火口丘とに相次いで起つた複噴火で，昭和 15 年 7 月 12 日から翌月 5 日頃までの約 25 日間續き，同期間中に頻發した噴火は舊火山體を破壞し，その地形を著しく變化せしめる様な激烈な爆發を起さなかつたが，噴火地帶内に新噴出物を堆積せしめ若干の新しい地形を形成した．即ち山腹地帶では，A 乃至 H の總計 22 に達する新噴出孔が生じ，何れも火山砂礫，火山彈等を拋出し，また B′，D，及び G 火口は夫々赤場曉，ヨリダイ澤，及瓢箪山熔岩流を流出せしめた．また山頂噴火地帶では，舊中央火口丘上に第一，第二，及び第三丘より成る新複合火口丘が生じ，少量の熔岩流が新熔岩臺地を形成した．本文では之等の噴火地帶に於ける新噴出孔の配列，新噴出物の分布及び量，地形變化等に就いて考察した．(未完)

Fig. 59. July 19, 1940. Cone *A*, looking south. Photo Tsuya.

Fig. 60. Oct. 25, 1940. Northern inside wall of crater *A*. *Sp*: New ejecta. *As*: Old ground. Photo Tsuya.

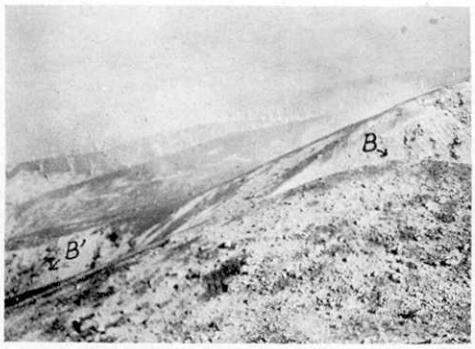

Fig. 61 a. July 19, 1940. Crater *B*, looking south. Photo Tsuya.

Fig. 61 b. July 19, 1940. Crater *B*, looking south. Photo Tsuya.

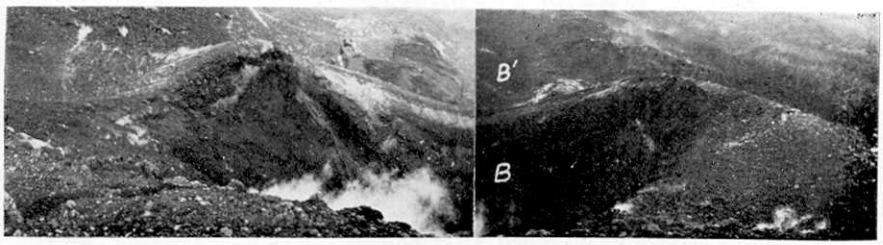

Fig. 61 c. Oct. 25, 1940. Crater *B*, looking east. Photo Tsuya.

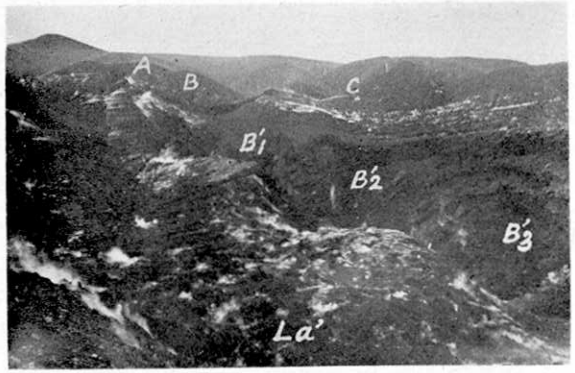

Fig. 62. Oct. 27, 1940. Craters $A \sim C$, looking west. *La'*: Akabakkyô lava-flow. Photo Tsuya.

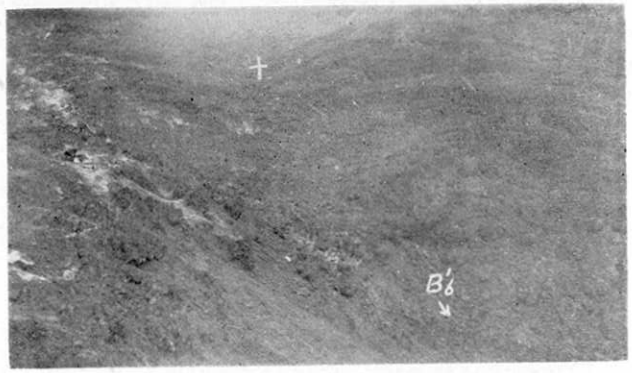

Fig. 63. Oct. 27, 1940. Crater B_6', looking north. Cross: The spot where a family consisting of 6 persons was buried beneath ejecta. Photo Tsuya.

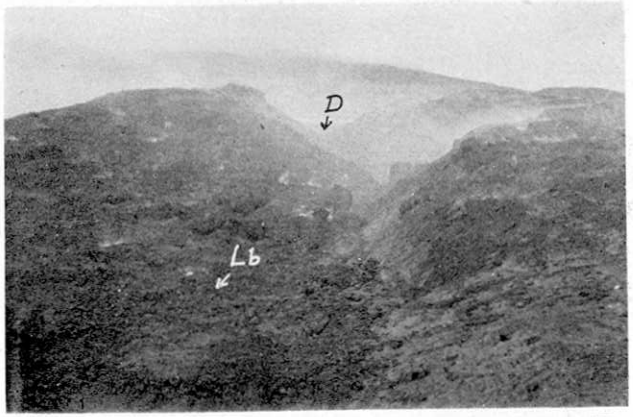

Fig. 64. Oct. 27, 1940. Crater *D*, looking west. *Lb*: Yoridai-sawa lava-flow. Photo Tsuya.

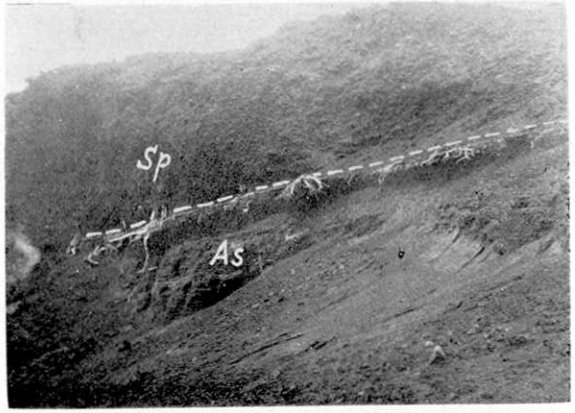

Fig. 65. Oct. 25, 1940. Southern inside wall of crater *D*. *Sp*: New ejecta. *As*: Old ejecta. Photo Tsuya.

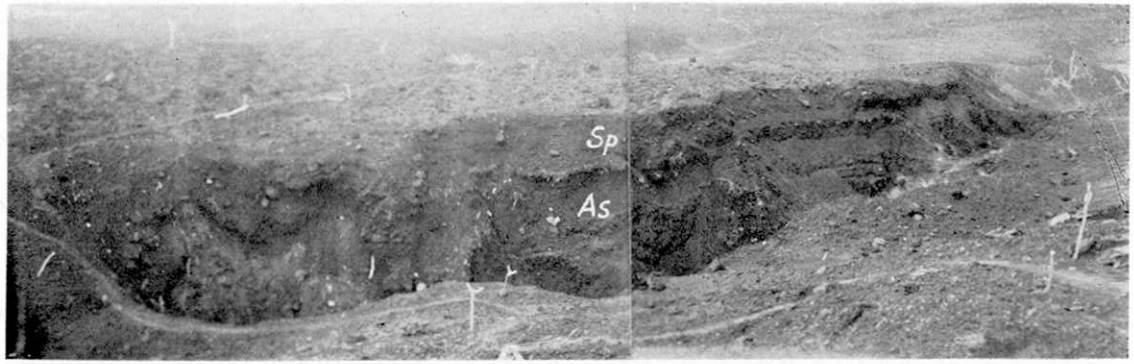

Fig. 66. Oct. 27, 1940. Craterlets *E*. *Sp*: New ejecta (volcanic sand and lapilli). *As*: Old ejecta (volcanic ash). Photo Tsuya.

Fig. 67 a. July 27, 1940. Crater *F*, now covered with volcanic bombs. Upper right, former sea-cliff of Akabakkyô-hana (point). Photo Tsuya.

Fig. 67 b. Nov. 2, 1940. Lower part of former sea-cliff of Akabakkyô-hana. Photo Tsuya.

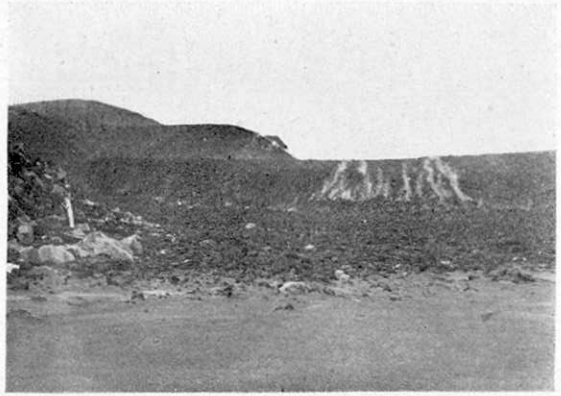

Fig. 68 a. Oct. 28, 1930. Western slope of Hyô-tan-yama, looking north. Photo Tsuya.

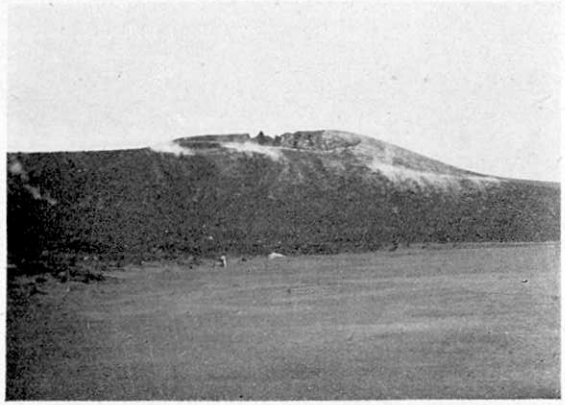

Fig. 68 b. Oct. 28, 1940. Western cone (*G*) of Hyôtan-yama, looking north. Photo Tsuya.

Fig. 68 c. July 20, 1940. Northeastern flank of eastern cone of Hyôtan-yama.
Photo Tsuya.

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Fig. 69. July 27, 1940. Akabakkyô lava platform, looking south from Nezumisama. Hyôtan-yama in left background. Former sea-cliff of Akabakkyô-hana in right background. Photo Tsuya.

Fig. 70a. July 27, 1940. Southern margin of Akabakkyô lava-platform. *La*: Akabakkyô lava. *Hb*: Hyôtan-yama bombs. Photo Tsuya.

Fig. 70b. July 21, 1940. NE margin of Akabakkyô lava-platform. Hyôtan-yama in the background. Photo Tsuya.

Fig. 70c. July 26, 1940. Northern margin of Akabakkyô lava-platform. Hyôtan-yama in background. Photo Tsuya.

Fig. 71. Oct. 28, 1940. New sand-beach on eastern margin of Akabakkyô lava-platform, looking north. Photo Tsuya.

Fig. 72. Oct. 28, 1940. Lake Sitori (*ls*) embanked on its eastern side by sand-beach (*S*). *La*: Akabakkyô lava. *M*: Former sea-cliff.
Photo Tsuya.

Fig. 73a. Oct. 27, 1940. Sea-cliff on eastern side of Hyôtan-yama, looking south.
Photo Tsuya.

Fig. 73 b. Oct. 28, 1940. Sea-cliff on SE side of Hyôtan-yama, looking north.
Photo Tsuya.

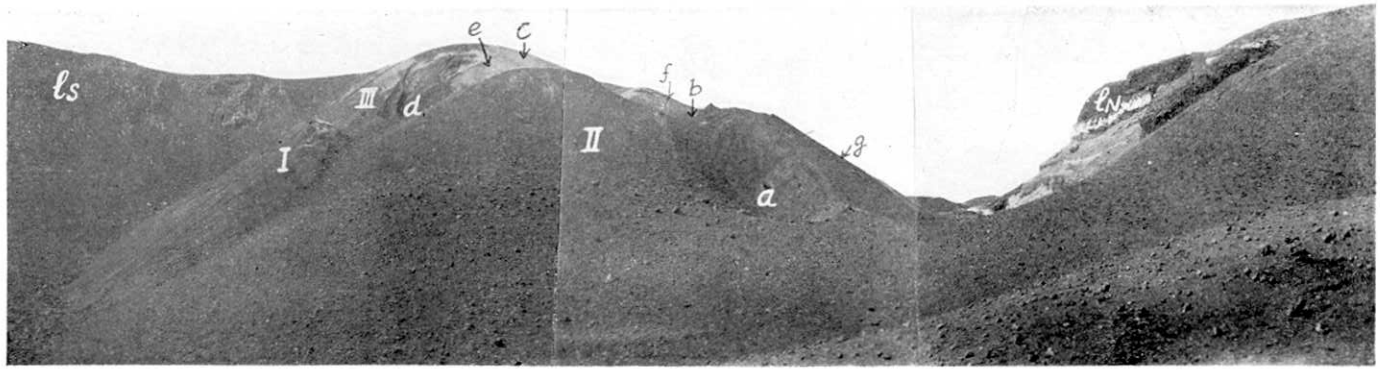

Fig. 74. Oct. 26, 1940. New central cone, looking west from floor of eastern crater. *I*: First cone. *II*: Second cone. *III*: Third cone. *a*~*g*: craters. *l*S: Inside S wall of Oana. *l*N: Inside N wall of Oana.

Photo Tsuya.

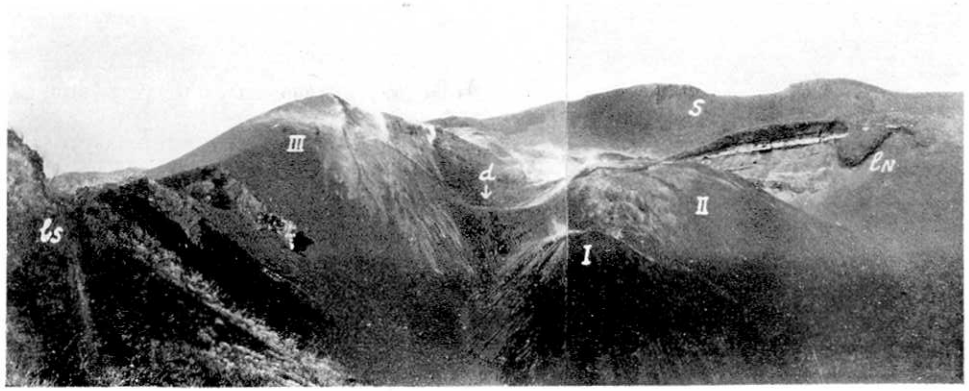

Fig. 75. Oct. 26, 1940. New central cone, looking northwest from S rim (*l*S) of Oana crater. *I*: First cone. *II*: Second cone. *III*: Third cone. *d*: Crater *d*. *l*N: Northern wall of Oana. *S*: Somma.

Photo Tsuya.

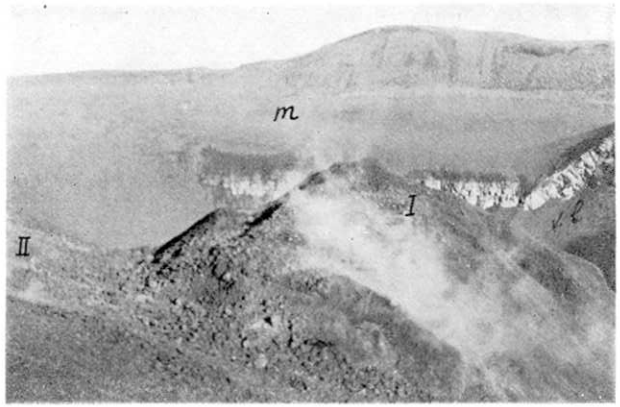

Fig. 76. Oct. 29, 1940. Top of first cone (*I*). *II*: S slope of second cone. *l*: Oana crater. *m*: Bottom of old eastern crater. Photo Tsuya.

Fig. 77. Oct. 29, 1940. Bottom of crater *a* on NE slope of second cone. Photo Tsuya.

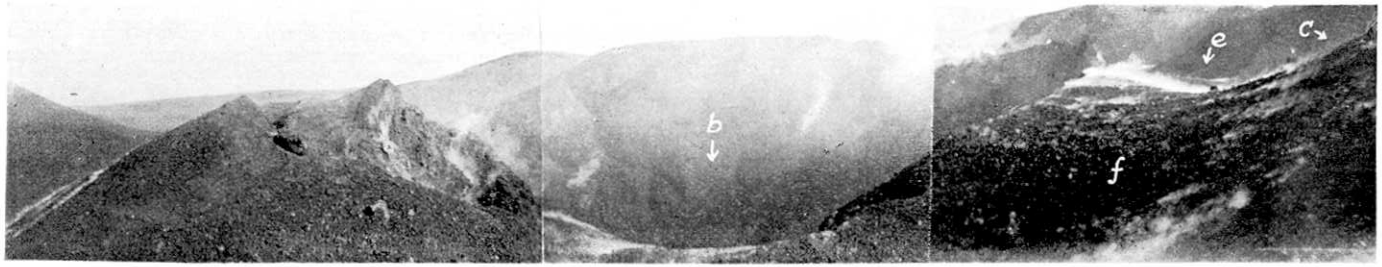

Fig. 78. Oct. 26, 1940. Crater *b* on top of second cone. *c*: crater *c*. *e*: crater *e*. *f*: crater *f*. Photo Tsuya.

Fig. 79. Oct. 26, 1940. SW wall of crater *c* on third cone. Photo Tsuya.

Fig. 80. Oct. 29, 1940. Bottom of crater *d* on border between second and third cones. Photo Tsuya.

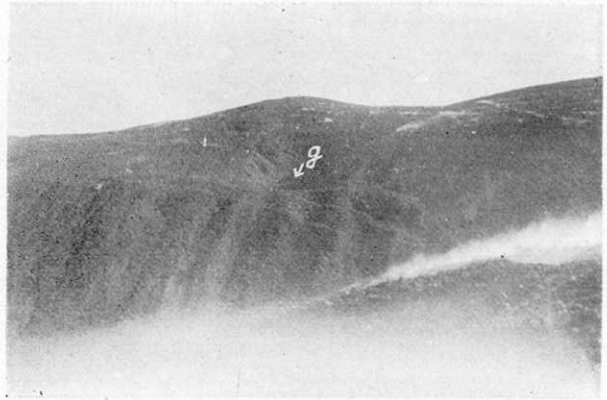

Fig. 81. Oct. 29, 1940. Crater *g* on northern flank of second cone. Photo Tsuya.

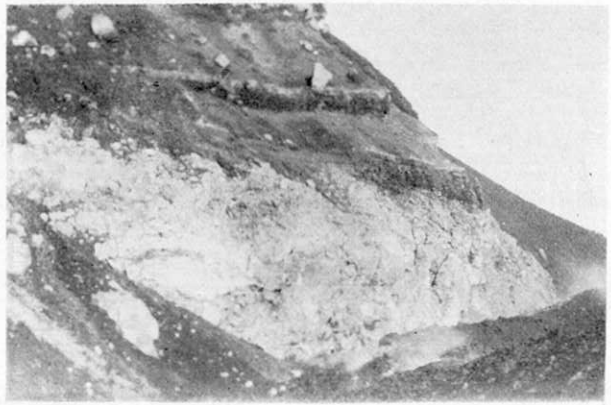

Fig. 82. Oct. 26, 1940. Lower part of inside N wall of Oana crater. Photo Tsuya.

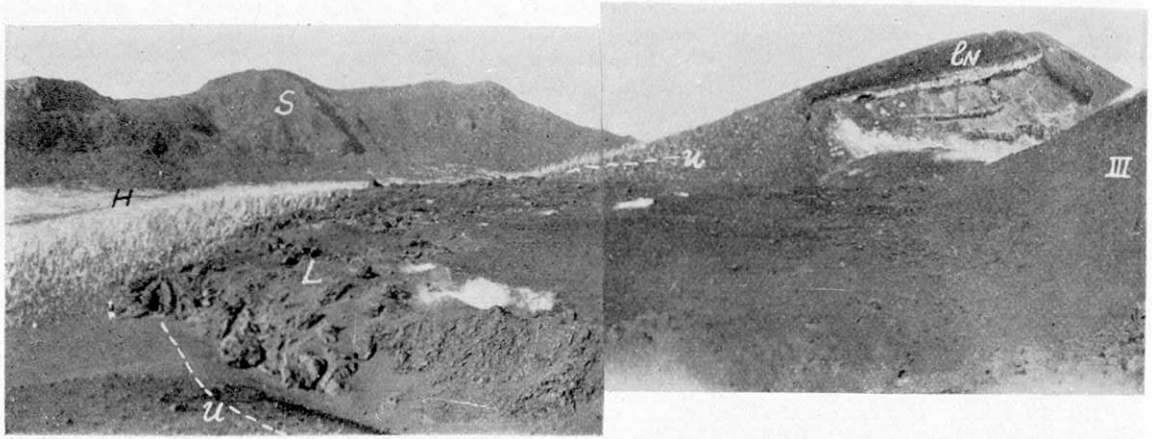

Fig. 83 a. Oct. 26, 1940. View of NW foot of new central cone, looking north. *III*: NW slope of third cone. L: New lava-coulee. *l*N: N wall of Oana crater. *u*: Upper rim of upper crater. *H*: Hayono-tairo atrio. *S*: N somma. Photo Tsuya.

Fig. 83 b. Oct. 26, 1940. Front of lava-coulee. Photo Tsuya.

Fig. 84. Oct. 26, 1940. Top of N wall of Oana crater (*l*N in Fig. 83 a), showing accumulation of juvenile and accessory ejecta (sand, lapilli, and bombs). Photo Tsuya.

Fig. 85. Oct. 26, 1940. Summit of new central cone, looking south. Upper right, fumaroles indicating fissure-lines. *b*~*g*: craters. *ls*: Southern rim of Oana crater. Photo Tsuya.

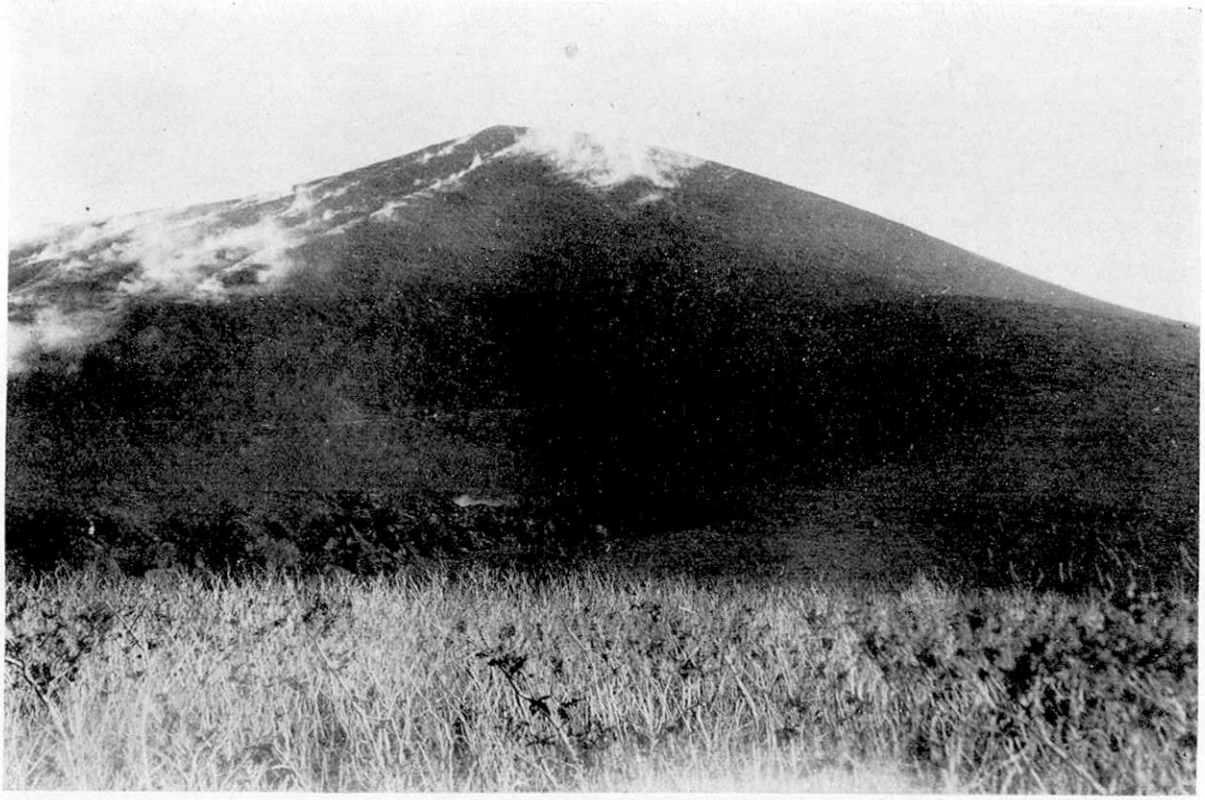

Fig. 86. Oct. 26, 1940. New central cone, looking southeast. Upper left, fumaroles indicating fissure-lines. Lower left, SW part of new lava-coulee. Lower right, SW rim of upper crater.

Photo Tsuya.

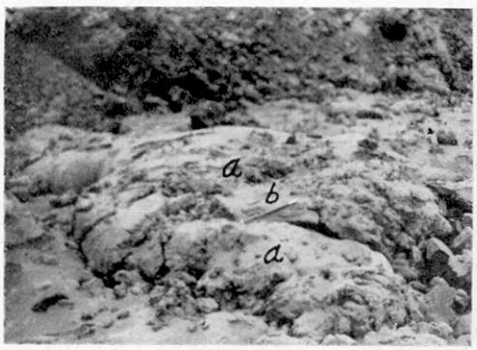

Fig. 87. July 27, 1940. Volcanic bombs at Sitori, piled one on top of the other. *a*: Porphyritic bomb, 7 m across. *b*: Aphanitic bomb, 2 m across. Photo Tsuya.

Fig. 88. July 17, 1940. Porous, aphanitic bomb partly imbedded in the ground. Photo Tsuya.

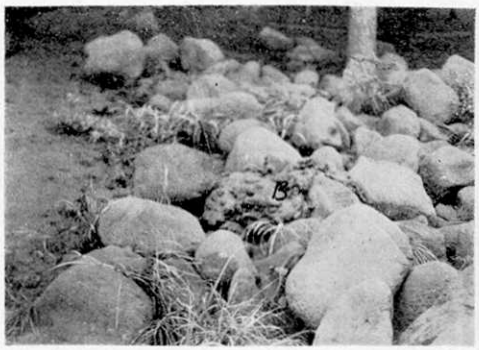

Fig. 89. July 27, 1940. Porous, aphanitic bomb (*B*) flattened by fall on the raised beach gravels. Photo Tsuya.

Fig. 90. Oct. 25, 1940. Bomb flattened by fall on a stump. Photo Tsuya.

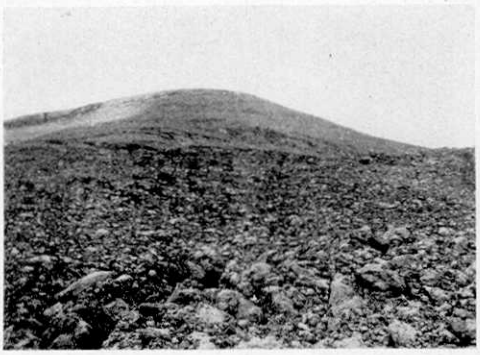

Fig. 91. July 20, 1940. The NW foot of Hyôtan-yama, showing accumulation of volcanic bombs. Photo Tsuya.

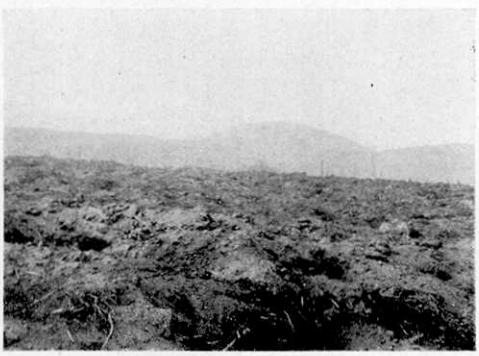

Fig. 92. July 17, 1940. Mountain slope near Yoridai-hana, showing hollows formed by falls of volcanic bombs. Photo Tsuya.

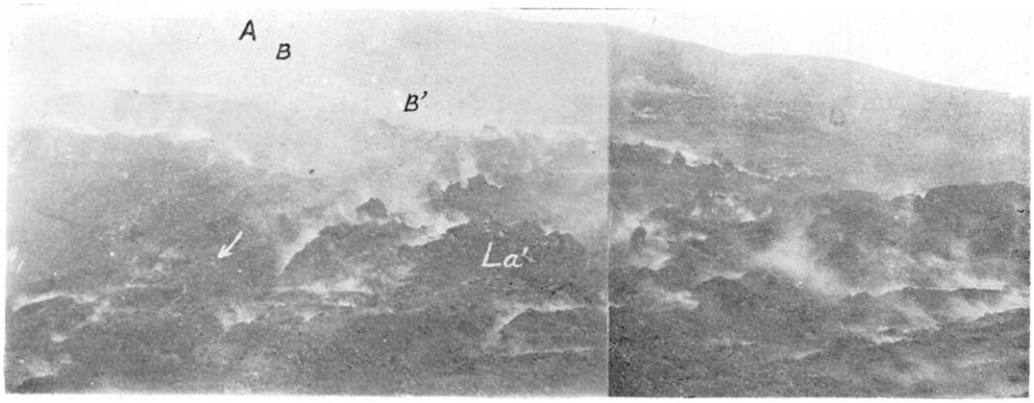

Fig. 93. Oct. 27, 1940. Akabakkyô lava-flow (*La'*) on the mountain slope adjoining the southern side of *B'* crater. *A*, *B*, *B'*: craters. l_1: Dammed pond. Photo Tsuya.

Fig. 94 a. Oct. 25, 1940. Dammed pond, l_1 in Fig. 93. *La'*: Akabakkyô lava. Photo Tsuya.

Fig. 94 b. Oct. 27, 1940. The southeastern branch of Akabakkyô lava-flow (*La'*). l_1: Dammed pond. Photo Tsuya.

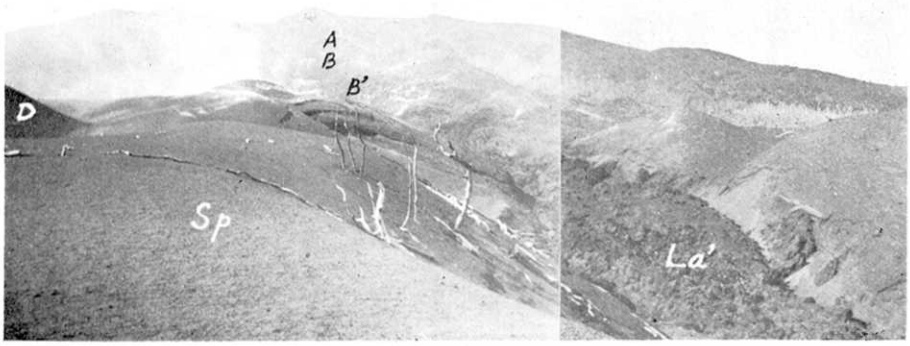

Fig. 95. Nov. 2, 1940. Akabakkyô lava-flow (*La'*) in the boundary valley between Kamituki and Tubota. *A*, *B*, *B'*: craters. *D*: Northern slope of cone *D*. *Sp*: Volcanic sand and lapilli. Photo Tsuya.

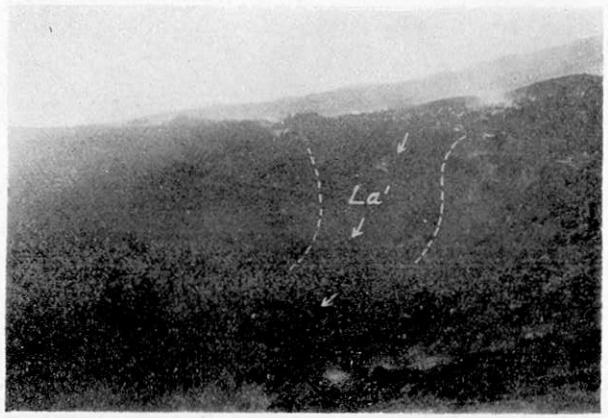

Fig. 96. Oct. 27, 1940. View across the boundary valley between Kamituki and Tubota, showing Akabakkyô lava (*La*) hanging over southern wall of valley.
Photo Tsuya.

Fig. 97. Nov. 2, 1940. Akabakkyô lava-flow on floor of boundary valley between Kamituki and Tubota.
Photo Tsuya.

Fig. 98. Nov. 2, 1940. Akabakkyô lava-flow near mouth of boundary valley between Kamituki and Tubota.
Photo Tsuya.

Fig. 99. July 26, 1940. Nezumisama, a small rocky hill in Simasita, left uncovered by the Akabakkyô lava (*La*). *H*: Hyôtan-yama. *D*: Former sea-cliff of Akabakkyô-hana.
Photo Tsuya.

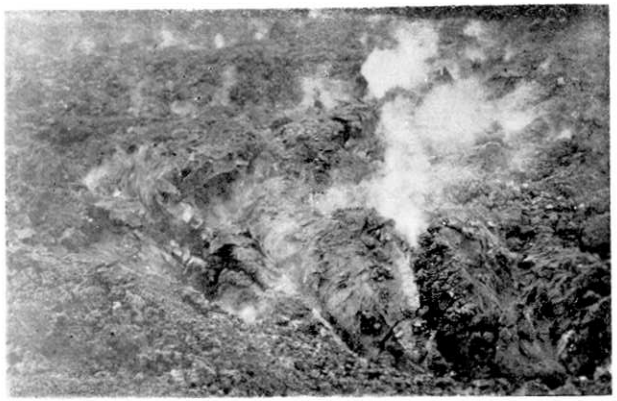

Fig. 100 a. Nov. 2, 1940. Contraction fissures in Akabakkyô lava. Photo Tsuya.

Fig. 100 b. Nov. 2, 1940. Do. Photo Tsuya.

Fig. 101. July 15, 1940. Steep marginal slope of Akabakkyô lava-flow at Simasita. Photo Tsuya.

Fig. 102. July 26, 1940. A cliff at Sitori, showing compact part (*A*) of the Akabakkyô lava. *S*: An old lava exposed on the coast of Sitori. Photo Tsuya.

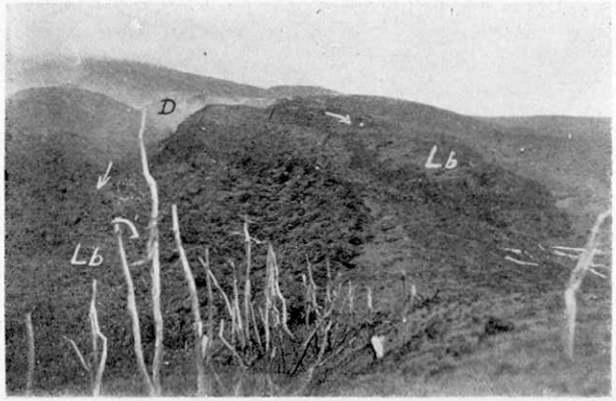

Fig. 103. Oct. 27, 1940. Yoridai-sawa lava-flow near its source. *D*: Crater. *Lb*: Lava-flow.
Photo Tsuya.

Fig. 104. July 17, 1940. Farthest front of the Yoridai-sawa lava-flow. Photo Tsuya.

Fig. 105. Oct. 27, 1940. Lava-flow in the middle course of the Yoridai-sawa, looking downstream from the lava-fall (left). Photo Tsuya.

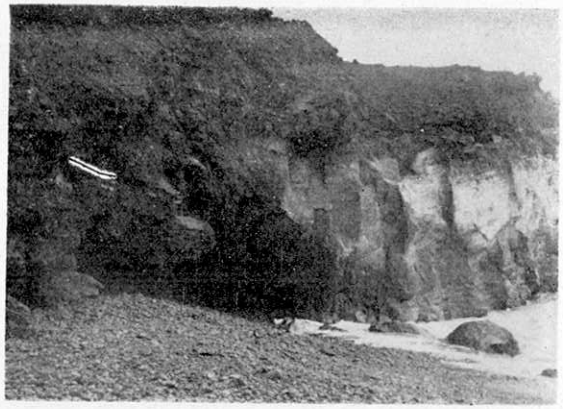

Fig. 106 a. Oct. 28, 1940. Lava-flow exposed in sea-cliff on SE coast of Hyôtan-yama.
Photo Tsuya.

Fig. 106 b. Oct. 28, 1940. Sea-cliff on eastern side of Hyôtan-yama, looking south. *Lc*: Hyôtan-yama, lava-flow. *Sb*: Volcanic sand, lapilli, and bombs. Photo Tsuya.

Fig. 106 c. Oct. 28, 1940. Hyôtan-yama lava-flow exposed on sand-beach adjoining northern end of sea-cliff shown in Fig. 106 b. Photo Tsuya.

Fig. 107. July 22, 1940. Trees bent and withered by ash-fall. Photo Tsuya.

Fig. 108. July 16, 1940. Tree trunks blasted by fall of lapilli. Photo Tsuya.

Fig. 109. July 19, 1940. Tree trunks blasted by fall of volcanic bombs and lava-blocks. Photo Tsuya.

Fig. 110. July 16, 1940. House in Mitoribata near Maru-yama burned by fall of incandescent volcanic bombs. Photo Tsuya.

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