# THE SAKURA-JIMA ERUPTIONS AND EARTHQUAKES.

## III.

## [Course of Activity in the Sakura-jima Eruption of 1914.]

By

**F. Omori, Sc. D.,**

Member of the Imperial Earthquake Investigation Committee.

*With Plates* XXXIII–LXX.

### Chapter I. Craterlets and Lava Sources.

**1. Zonal arrangement of eruptive vents.** In the Sakura-jima eruption of 1914 numerous openings have been formed on two opposite flanks of the mountain. These are arranged on the whole along a nearly straight zone through the centre of Minami-dake, or the South Peak, extending in an E.S.E. and W.N.W. direction approximately normal to the line of the great volcanic chain, which connects the centre of Sakura-jima with Kirishima on the N.E.N. and Kaimon-dake, Iwo-jima, Suwanose-jima, etc., on the S.W.S. (See fig. 2, Pl. IX, in the preceding Number of the Bulletin.) The eruption zone meets at an angle of about 60° the central ridge of the island running in the N. and S. direction.

The eastern craterlets series, whose horizontal extension is about $2\frac{1}{2}$ km and whose lower half crosses obliquely the southern limb of the U-shaped ridge of Nabe-yama, has been formed within the original height limits of 470 and 140 m above sea-level, the lava

having thence streamed down mostly sideways to the S.E. portion of the island. On the western side the craterlets extend over the space of the horizontal length of about 2.6 km within the original height limits of 570 and 65 m above sea-level, whence the lava ran down westwards along the valley between Hikinohira and Atago-yama on the south and the hill group of 120 to 400 m height above the village of Akobaru on the north.

On the eastern side, there have been formed several large and small craterlets, all these being connected by a distinct eruption canal or crack. On the western side, where there remains no evident trace of a similar opening, the highest craterlet is the only large one existing in the well preserved condition, the different vents in the lower levels having probably in a part been filled up by the lava streams which flowed over them.

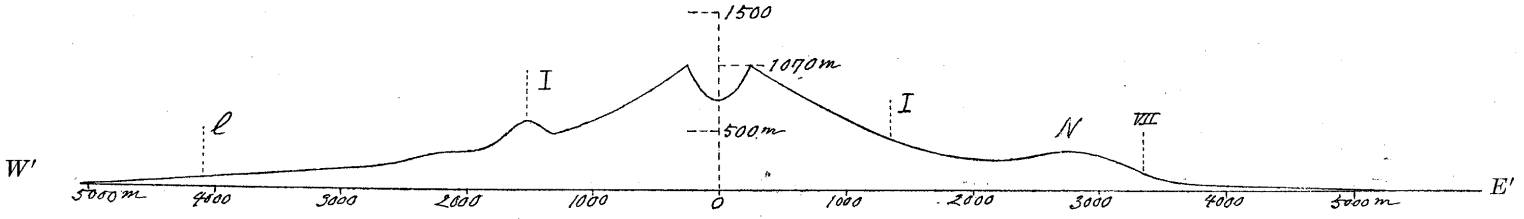
In fig. 1 is shown the original outline of Sakura-jima in the vertical plane through the centre of Minami-dake and the eruption zone, while in figs. 2 and 3 are given the profiles respectively of the E.S.E. and W.N.W. slopes of Minami-dake, both before and after the eruption, with indications of the positions of the different craterlets.[1)]

**2. Craterlets on eastern side.** The volcanic fissure, or zone of eruptive vents, on the eastern side extends along a slightly zigzag line in a general W.N.W.–E.S.E. direction, including amongst the others 7 well-defined large craterlets 100 m or more in diameter. (See figs. 75, 77, and 88.) I have visited the No. 1 craterlet and the highest epening first at the time of my second trip to Sakura-jima in April 1914, when the No. 2 and other lower craterlets were still in active conditions. A detailed inspection of

1. The profiles have been drawn with reference to the Military Survey maps of Sakura-jima of 1:50.000 published in 1912, and one of 1:25,000 completed after the eruption, in 1915.

**Fig. 1.** Sectional Outline of Sakura-jima in the E.S.E. and W.N.W. Direction through Minami-dake, before the Eruption of 1914.

E'.....E.S E. Coast. W'.....W.N.W. side, corresponding to
N .....Nabe-yama. the E. base of Hakamagoshi.
I, VII.....Positions of the eastern craterlets Nos. 1 and 7.
I, 1.....Positions of the highest and lowest western craterlets.




**Figs. 2 and 3.** Section of Sakura-jima along the Eruption Fissure through Minami-dake : Diagrams showing the Heights and Successive Mutual Distances of the Craterlets.

Full line gives the contour after, and the dotted line that before, the recent eruption.

**Fig. 2.**

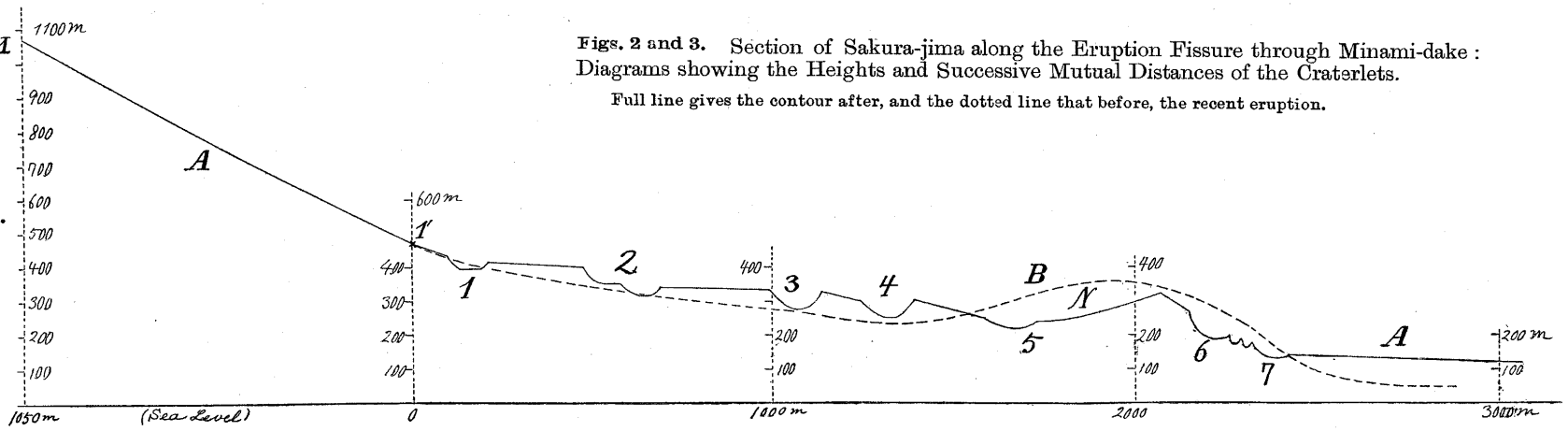



Fig. 2. Craterlets Series on the Eastern Side.
1' 1, 2, 3, 4, 5, 6, 7.....Craterlets Nos. 1', 1, 2, 3, 4, 5, 6, 7 respectively.
N.....Nabe-yama. M .....East rim of Minami-dake Crater.

**Fig. 3.**

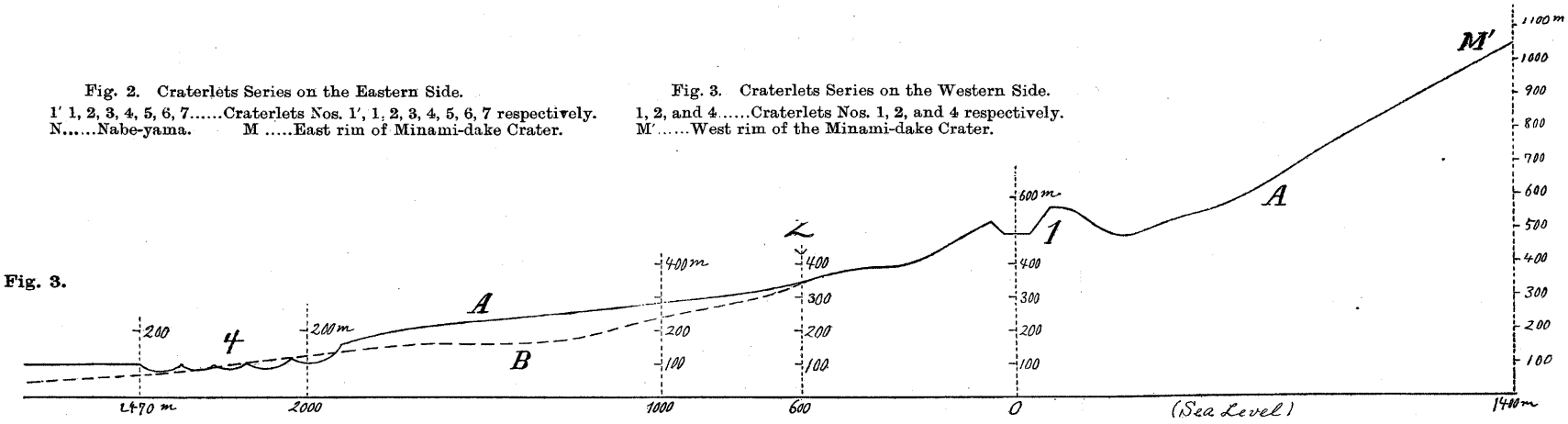
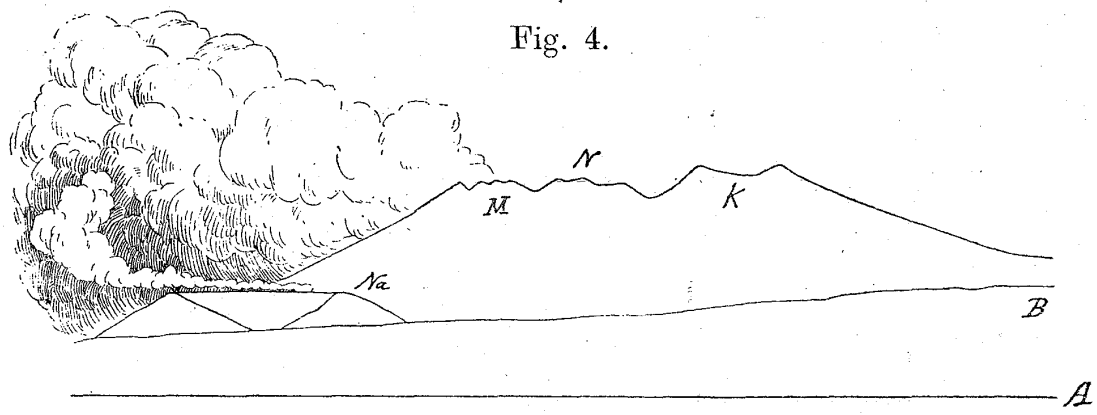



Fig. 3. Craterlets Series on the Western Side.
1, 2, and 4.....Craterlets Nos. 1, 2, and 4 respectively.
M'.....West rim of the Minami-dake Crater.

the different craterlets along the entire eruption zone was effected later on at the times of my 4th and 5th trips, in April and September, 1915. The craterlets are numbered 1 to 7 in order of descending height.

*Highest No. 1′ vent or "chimney."* The highest vent is a lateral opening, situated at the height of 470 m above sea-level and at the base of a shallow horse-shoe shaped depression on the S.E. flank of Minami-dake. This formed neither an explosive craterlet nor a mouth for lava outflow, but simply a sort of factory chimney, which sent, when seen on Jan. 16th, 1914, white smokes vigorously forward in a slanting down-slope direction over and to the south of Nabe-yama. (See figs. 4 and 76.) The opening whose inner channel might not extend backward

Fig. 4.




Sakura-jima seen from West: Sketch showing the sidewise ejection of white smokes from the "Chimney," or the highest East side No. 1′ Vent.
K.....Kita-dake. N.....Naka-dake. M.....Minami-dake. Na.....Nabe-yama.
A.....Sea-level. B.....Plateau ground.

horizontally must have been above the surface level of the interior molten lava mass. When again seen in April 1914, the white smokes, whose ejection was no longer strong enough to take place in a straight sidewise course, were given out diffusedly, but in no insignificant amount, from the main original mouth, a hole $1\frac{1}{2}$ m in dimension, with some sulphur deposits, and from a

number of small sources situated along a fissured zone, about 9 m in width, extending obliquely upwards for the length of about 35 m.

*No.* 1 *craterlet.* (See fig. 90.) The proper No. 1 or highest craterlet is a conspicuous circular hole of the mouth diameter of 120 m, situated 90 m below the "chimney" at the foot of a horse-shoe slope before noted and on the eastern flank of a sort of a small plateau-like elevation. In April 1914 it has been found to be completely dead and smokeless, the bottom plane, 51 m in diameter, being filled with sand. On the upper or western end, where the rim is highest and is situated 435 m above sea-level, the steep inside wall, 41 m in depth, is made up entirely of hard massive gray lava forming the original rocky layer of the Minami-dake slope, with a covering of the new ejected material. The craterlet in question was essentially explosive in nature and its activity has probably been limited only to a short time interval at the commencement of the eruption, as it had already ceased to make outburst before Jan. 16th, 1914. The lava outflow seems here to have taken place chiefly from a small deep hole at the lower side of, and separated by a single rocky partition from, the No. 1 craterlet, chiefly toward the south.

*Eruption canal between No.* 1 *and No.* 2 *craterlets.* (See fig. 77.) The lower side of the No. 1 craterlet is continued to the shallow "eruption canal" in an E.S.E. direction pointing toward the S. shoulder of Nabe-yama, throughout which outbursts must have taken place in the earlier stage of the eruption and along which traces of numerous secondary craterlets are remaining. Amongst the others there were two of these latter on the S. side or bank of the canal, which were respectively 35 and 17 m in mouth diameter, both abundantly emitting pungent sulphurous gases even at the end of 1915. For the length of the first 128 m,

the canal was about 20 m in depth, and the broad flat bottom, about 100 m in width, was filled with pumice. Thereafter it bifurcates into two narrow branches, of which the northern one is continued for about 130 m till it reaches the head of the No. 2 craterlet. Around the No. 1 craterlet, especially on the higher ground to its S. and S.W., and on the elevated south bank of the canal, there were great many large blocks of lava, 4 metres or more in dimension, evidently thrown out during the active eruptive epoch.

*No. 2 compound craterlet.* The 2nd large U-shaped craterlet, whose total length is 220 m, and whose upper rim is 400 m above sea-level, is composed of two circular cavities No. 2, A and No. 2, B situated in close proximity, and at different levels such that the bottom of the higher one is continued to the head of the lower. The upper cavity (2, A) whose west side wall is steep and composed of massive gray rocks of the old existence is 50 m deep and 120 m long, while the lower one (2, B) is shallow and is 34 m deep and 100 m long. Unlike the No. 1 craterlet these two cavities continued actively explosive for a long time, so that the bottoms, which were not filled with sand and pumice, as well as the adjacent grounds are covered thickly with blocks of projected lavas, apparently of later date, as these were not coated with ashes. In particular, at the S. brink of the upper cavity (2, A), there was a quite fresh-looking huge bread-crust bomb about 3 m in diameter (fig. 42).

The molten mass given out from the No. 2 craterlet is considerable in amount and covered the higher sloping ground which forms its N. boundary; a portion forced up the W. shoulder of Nabe-yama producing the lava cascade illustrated in fig. 84.

The distance between the lower end of the No. 2 craterlet and the head of the No. 3 craterlet is 300 m.

*No.* 3 *craterlet.* The 3rd craterlet is quite large and is, unlike the two higher ones, a perfect inverted cone, 60 m in depth, with an almost level circular mouth 150 m in diameter; the upper rim being at the height of 336 m above sea-level. The craterlet wall is made up of lava fragments of reddish colour, and there is no exposure of old native massive rocks. The distance between the lower end of the No. 3 craterlet and the head of the No. 4 craterlet is about 100 m.

*No.* 4 *craterlet.* (See fig. 91.) The No. 4 craterlet is also a magnificent and nicely cut conical cavity about 150 m in mouth diameter, whose northern margin is at the height of 297 m above sea-level; the depth being about 50 m, and the accurately regular reddish inner side, with exposure of no old rock masses, having a slope angle of 34.° When seen in April 1915, there was at the centre or bottom, an apparently loose heap of lava masses about 20 m in dimension. (See § 9.)

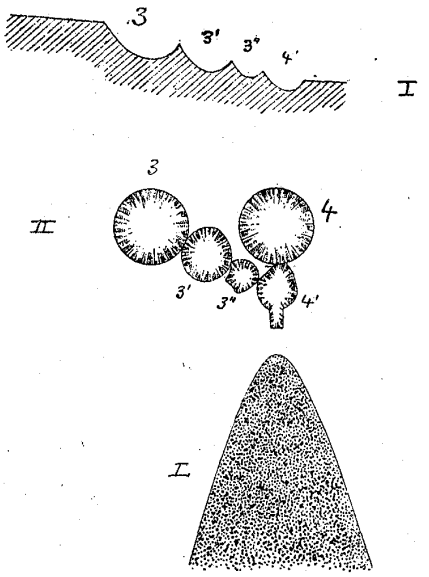



Fig. 5.

Sketch showing the Positions of the Eastern Craterlets Nos. 3, 3,′ 3,″ 4,′ and 4.

L.....Lava flow.

(I) .....Section through (3) and (4′).
(II).....Plan.

**Initial Phases of Sakura-jima Eruption.** Seen from Tarumizu 11½ km to the S. E. of the Centre of Sakura-jima, on the morning of Jan. 12th, 1914. (R. Higo, photo.)

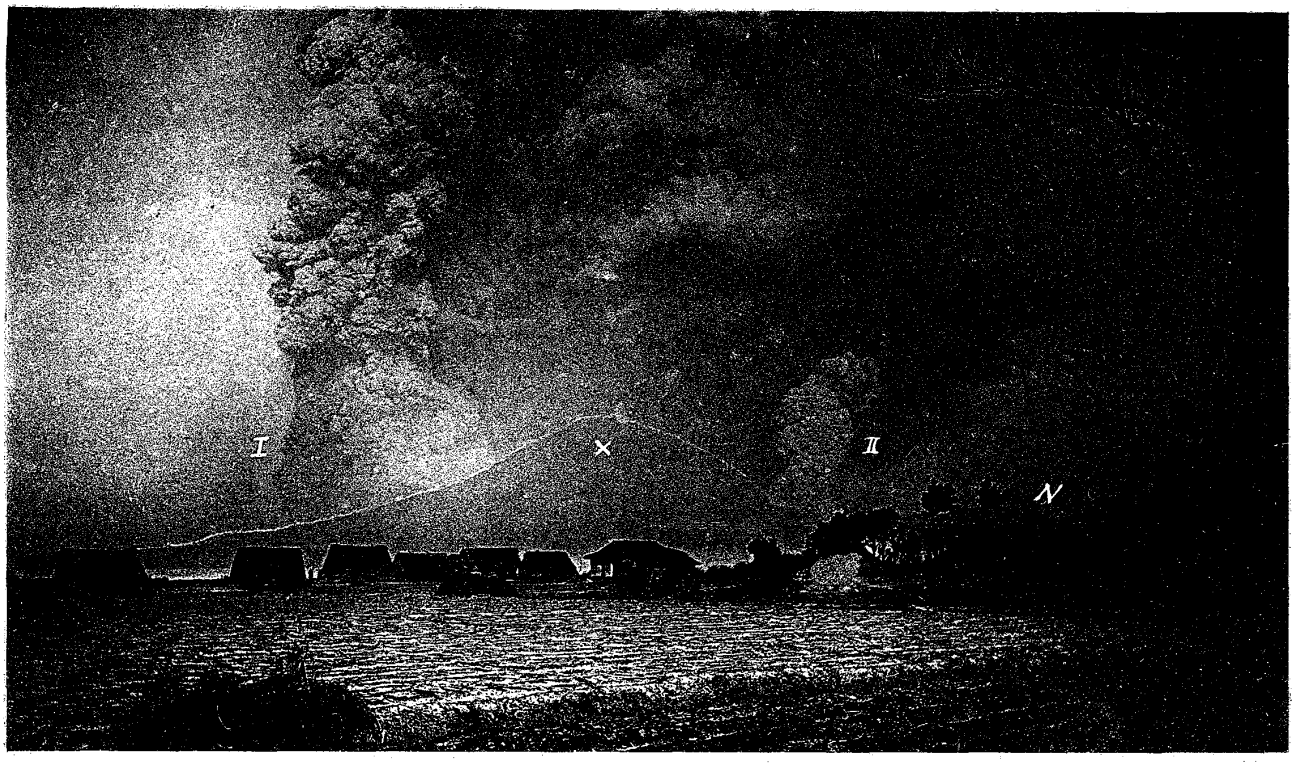



**Fig. 6.** View taken about 20 min. after the Commencement of the Eruption.

(×).....Sakura-jima (Minami-dake).
N .....Nabe-yama.
(I).....Eruption from the W. side.
(II).....Eruption from the E. side.

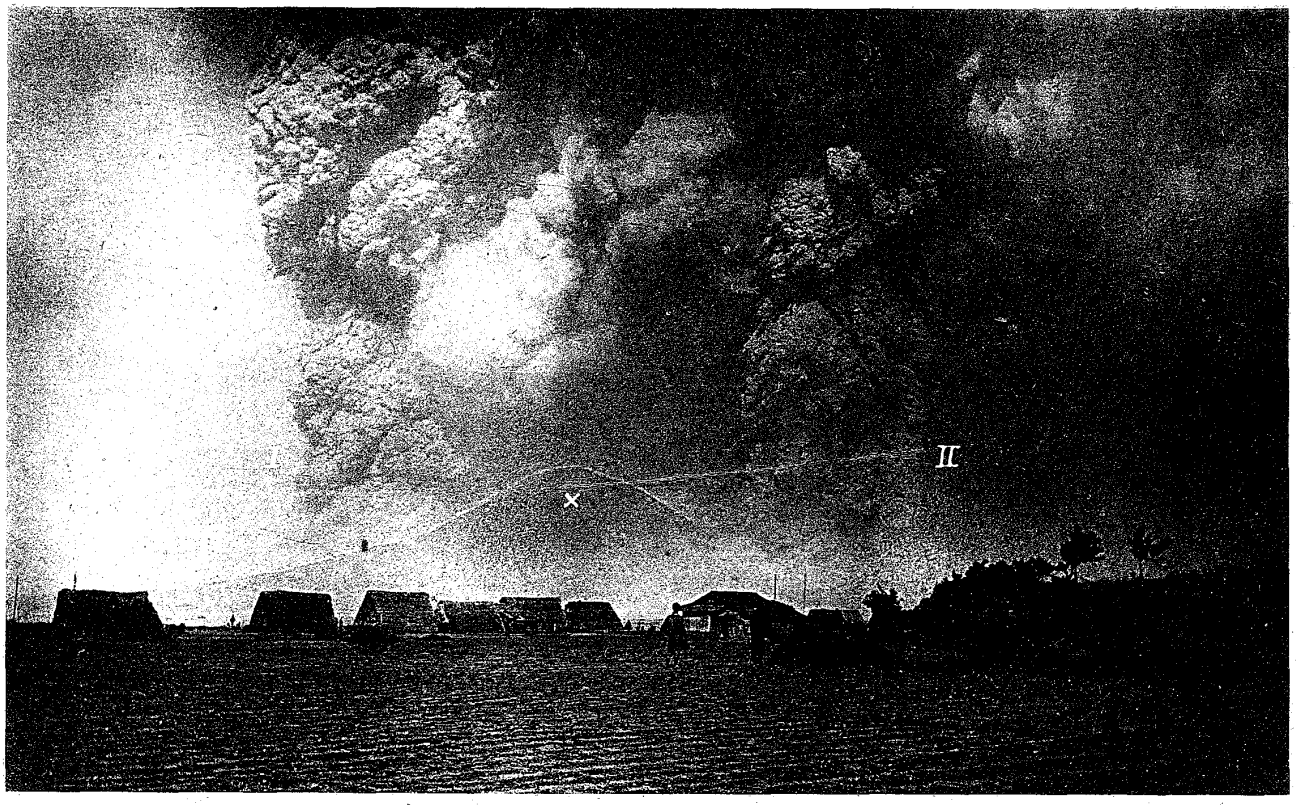



**Fig. 7.** View taken about 45 min. after the Commencement of the Eruption.

**Initial Phase of Sakura-jima Eruption.** Seen from Shiroyama Hill Park, Kagoshima.

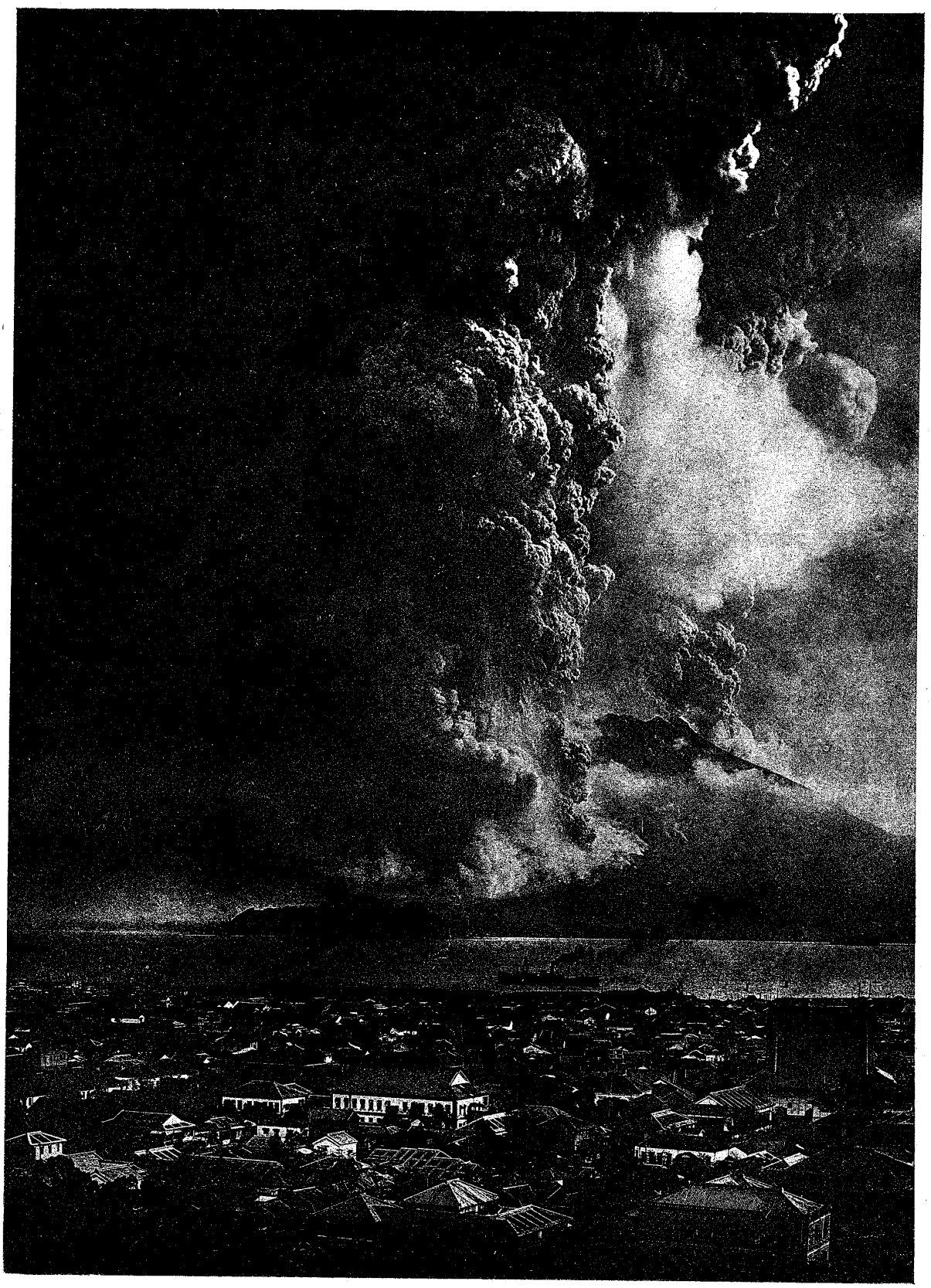


**Fig. 8.** View taken about 1 hour after the Commencement of the Eruption, or approximately at 11 a.m., on Jan. 12th, 1914.

**Sakura-jima before the Eruption of 1914.**

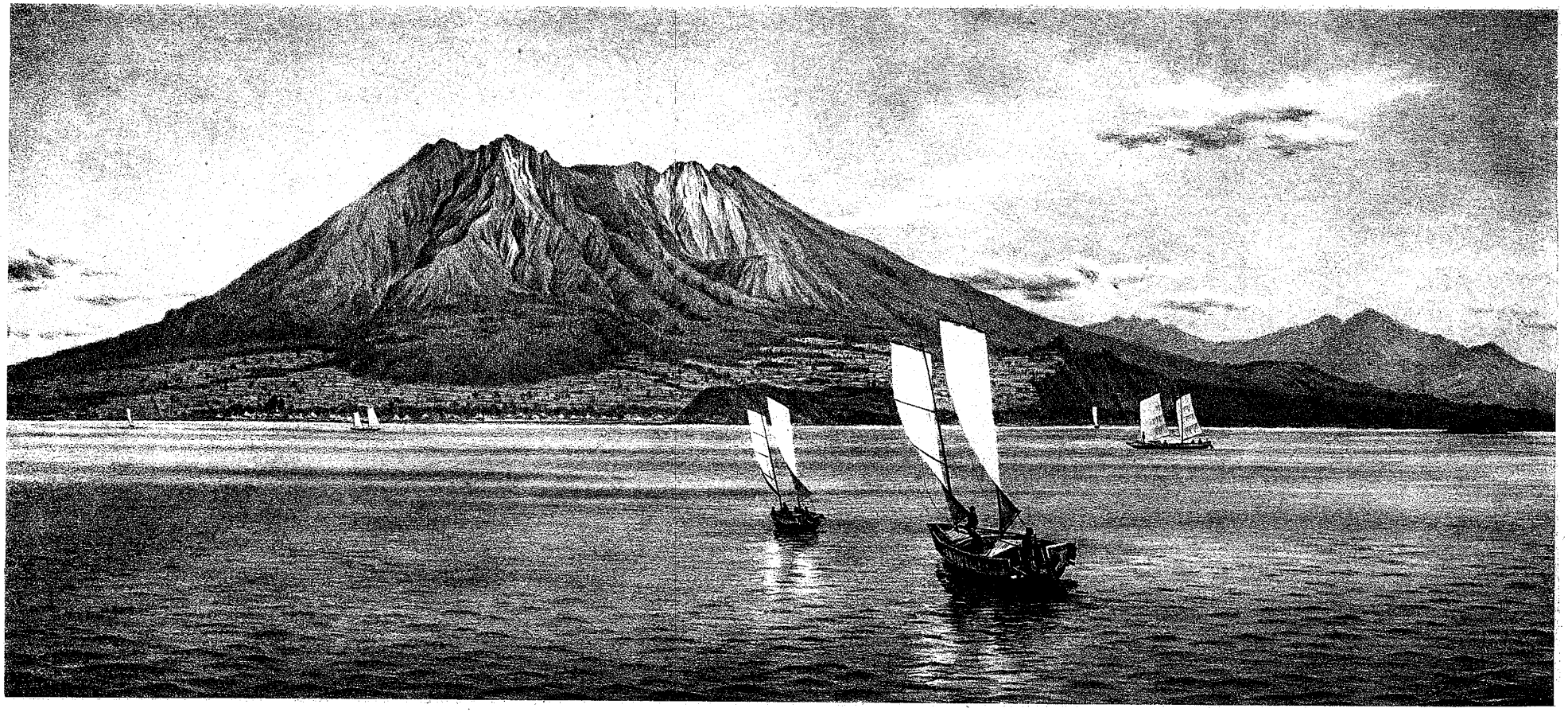


**Fig. 9.** Sakura-jima seen from Gion-no-su, the mouth of the Inari-gawa, at the N. part of Kagoshima. (From a sketch drawing made by Mr. Nanto Omure in 1909.)

**East and West Side Views of Sakura-jima.** (1), Hakamagoshi. (×), Nabe-yama.


**Fig. 10.** W. side view after the snow fall taken from Gion-no-su, Kagoshima, on Jan. 8, 1914, namely, 4 days before the Eruption. (C. Sugimoto, photo.)

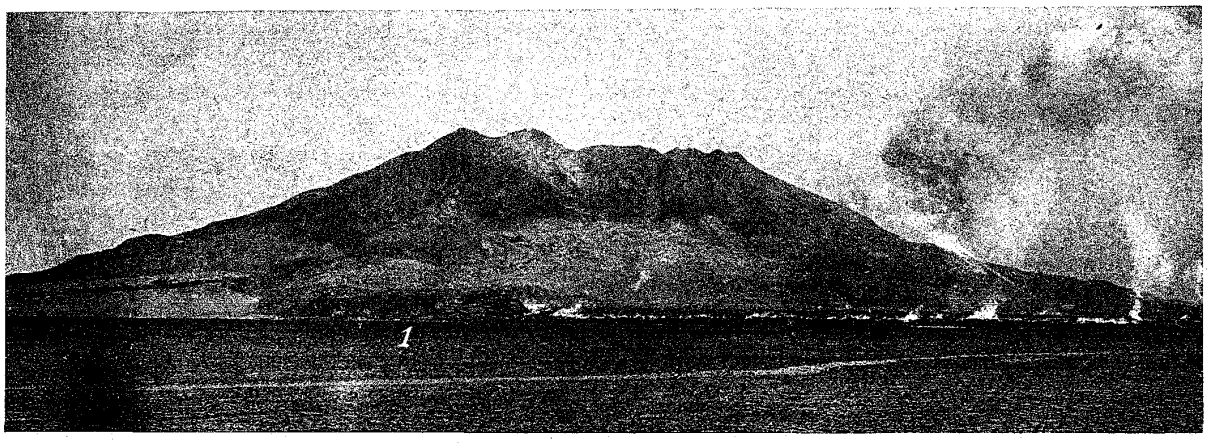



**Fig. 11.** View taken from nearly the same locality in Sept. 1915. (F. Omori, photo.)

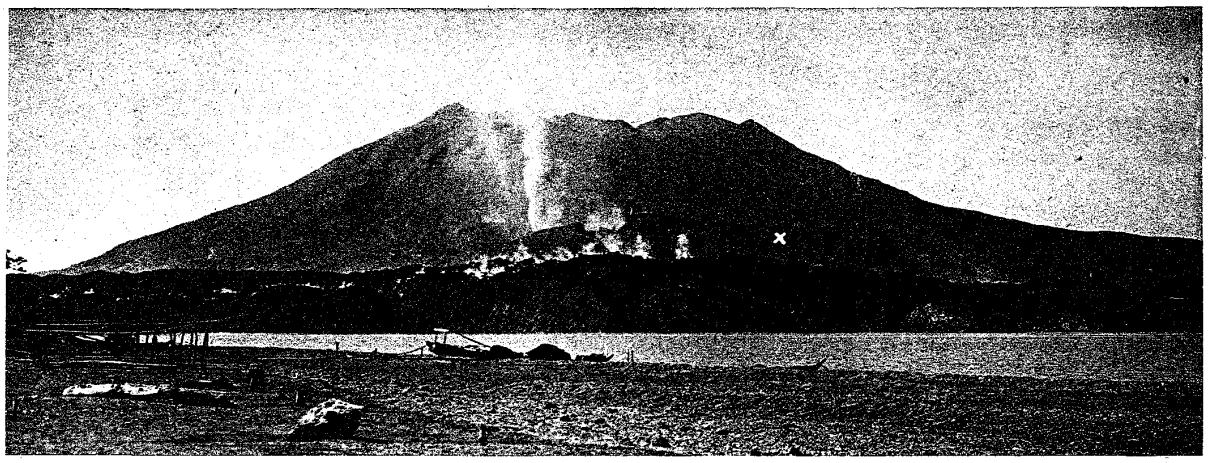



**Fig. 12.** E. side view taken from the shore of Ushine, indicating the annular Nabe-yama top behind the black lava bank at the front. (F. Omori, photo.)

**Sakura-jima in 1894.** (Sketches by Dr. T. Suzuki.)

1.....Minami-dake. 2.....Naka-dake. 3.....Kita-dake.
4.....Nabe-yama. 5.....Moe-jima. 6.....Nakano-shima.

Fig. 13.

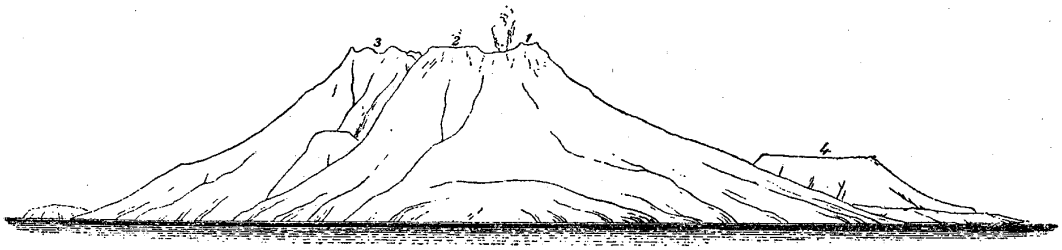



Fig. 14.

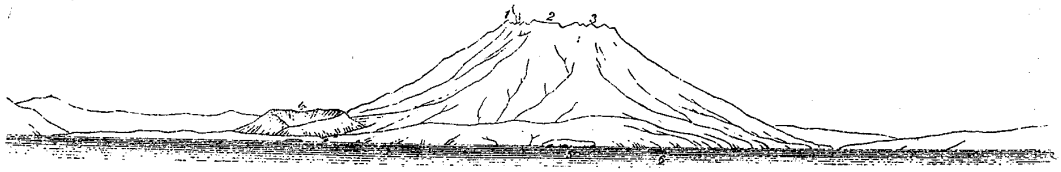



**Fig. 13.** View from Fukuyama 18 km to the N.E. of the centre of the island.
**Fig. 14.** View from Sesegushi 22 km to the S.W. of the centre of the island.

**View of Sakura-jima, showing the change of form of Nabe-yama before and after the Eruption of 1914.**
(1), Sakura-jima. (2), Nabe-yama. (3), Sakkabira.

Fig. 15.

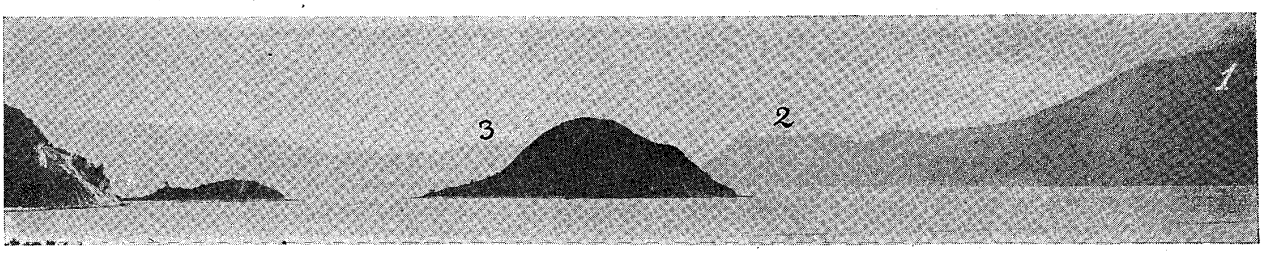



Fig. 16.


Fig. 17.

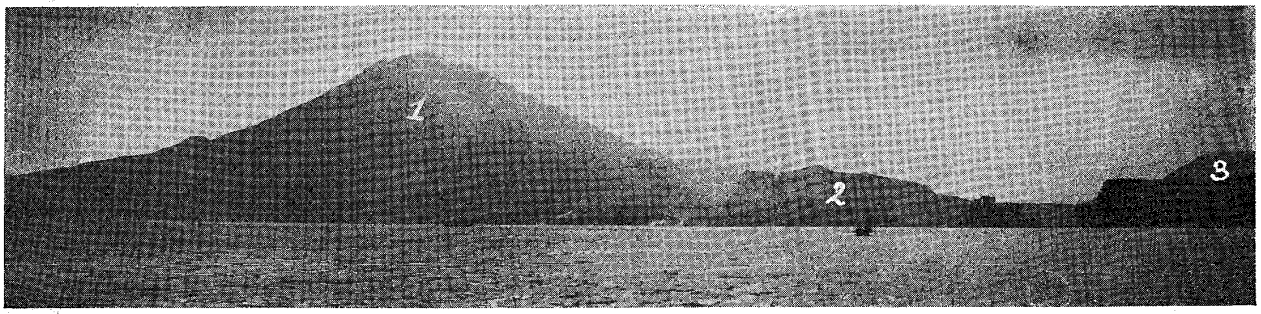



**Fig. 15** Picture taken, some years before the Eruption, from Hamanoichi (near Kokbu, at the N. coast of Kagoshima Bay), showing Kanzukuri-jima at the centre, and Nabe-yama immediately to the right.
**Fig. 16.** Sakura-jima seen from the mouth of Shin-kawa, near Hamanoichi, with Nabe-yama at the left-hand side base. (Sept. 3rd, 1914. F. Omori, photo.)
**Fig. 17.** Sakura-jima seen from the S., with Nabe-yama at the right-hand side base. (Sept. 25th, 1914. F. Omori, photo.)

The wall of the No. 4 craterlet is breached at the S. side, being there connected to a smaller secondary cavity No. 4′ (fig. 5), about 50 m in diameter, whose reddish inner side was constantly crumbling down. The cavity is separated from the black lava source only by a narrow ridge 228 m above sea-level, over which the air was still intensely flickering in Sept. 1915, and whose breadth was only 30 m. Below the No. 3 craterlet there are two more secondary craterlets Nos. 3′ and 3″ which are continued stepwise to No. 4′ at the lower level, together forming an inclined eruption fissure. (See fig. 75.)

**3. Craterlets on eastern side. (Cont.)** (See figs. 75, 87, and 88.)

*Nabe-yama eruption crack: western portion.* Proceeding 220 m

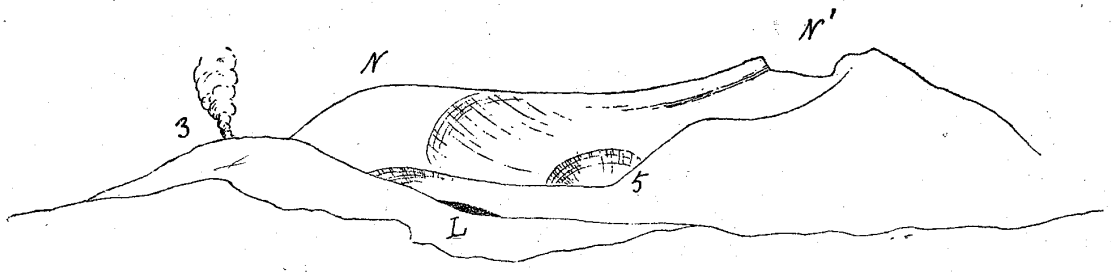



Fig. 18. Nabe-yama Eruption Crack seen from the West. (Sept. 27th, 1914.)
3.....Craterlet No. 3. N.....Highest point of Nabe-yama.
5.....Craterlet No. 5. N'.....Highest part (opening) of Nabe-yama Eruption Crack.
L.....Black Lava Source.

eastwards from the No. 4 craterlet we reach, at the bottom of a gentle valley, the border of the shallow craterlet No. 5 (fig. 18), whose diameter is about 150 m, and where commences the western branch of the Nabe-yama Eruption Crack, entirely covered with lava fragments. 250 metres more along the southern border of the crack zone bring us to the foot of the S. shoulder of Nabe-yama, whose present top, 321 m above sea-level, is reached after an ascent of further 280 m. In the crack zone, about 150 m in breadth, there are a number of traces of shallow craterlets in addition to the one above noticed.

*Nabe-yama eruption crack : eastern portion.* The S. portion of the Nabe-yama U-ridge, which is crossed by the Eruption Crack, has been much shattered and considerably reduced in height, as may be seen from a comparison of the photographs (figs. 15 and 16) taken from the vicinity of Hamanoichi before and after the eruption of 1914. Thus, before the eruption the top AB of Nabe-yama was flat, while at present it is much inclined

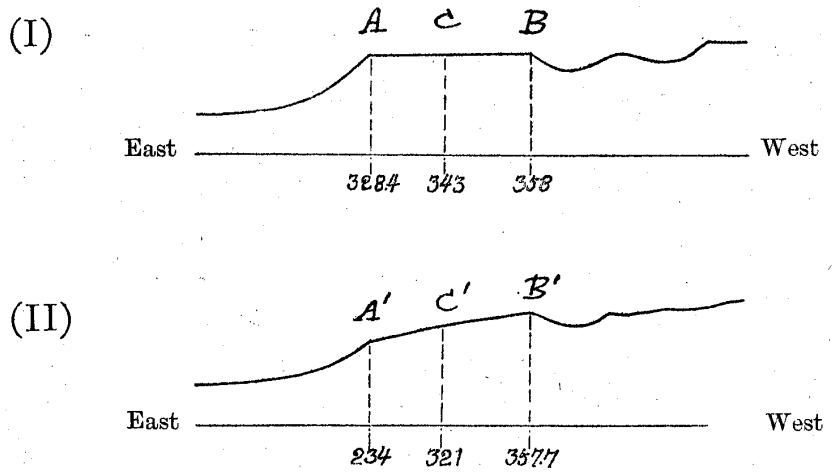



Fig. 19. Nabe-yama seen from North, (I) before and (II) after the Eruption of 1914.
AB (A'B').....Nabe-yama top.
B.....Highest point on the W. edge of the top ridge.
A..... „ „ „ „ E. „ „ „ „ „
C.....Position of the present highest point on the S.E. side, or the top cliffs of the eruption crack.
[B', C', A' correspond in position to B,C,A respectively.]

toward the east, (A'B' in fig. 19). Estimating from the photograph (fig. 15), the height of the point B before the eruption comes out to be 358 m, being accidentally equal to that of the new trigonometrical station on the highest point of Nabe-yama, which must have suffered elevation and depression during and after the volcanic disturbances, besides being coated with an accumulation of the ejected material. The height of the new shoulder point A', approximately corresponding in position to the former trigonometrical point

at A is about 234 m, the amount of truncation or height reduction being 94 m.

The eastern portion of the Eruption Crack is much deeper than the W. branch and is about 350 m in total length. At the head, 248 m above sea-level there is the large and regular circular explosion craterlet, No. 6, about 60 m in depth and 120 m in

Fig. 20.

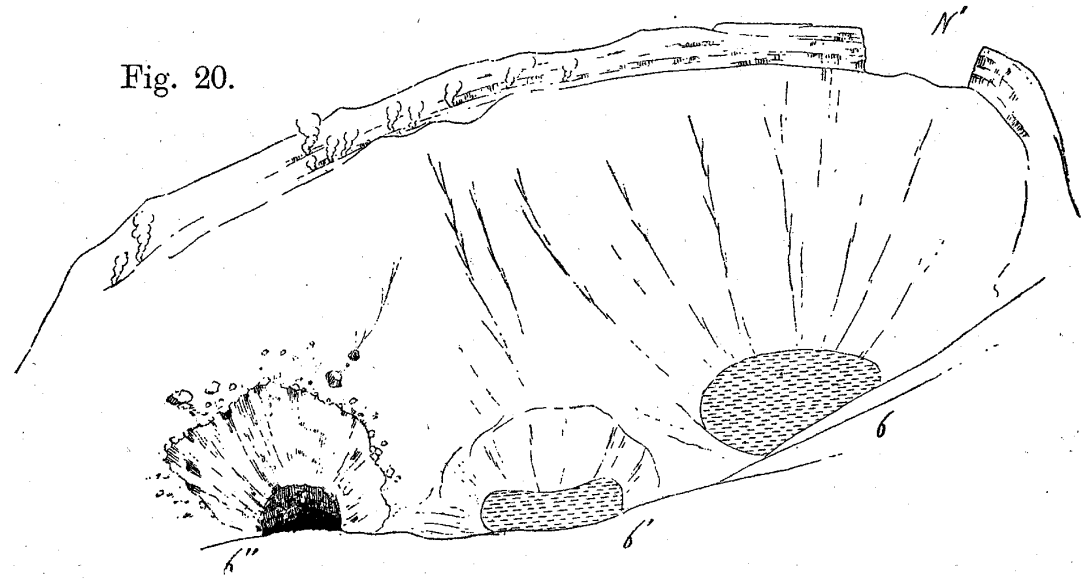
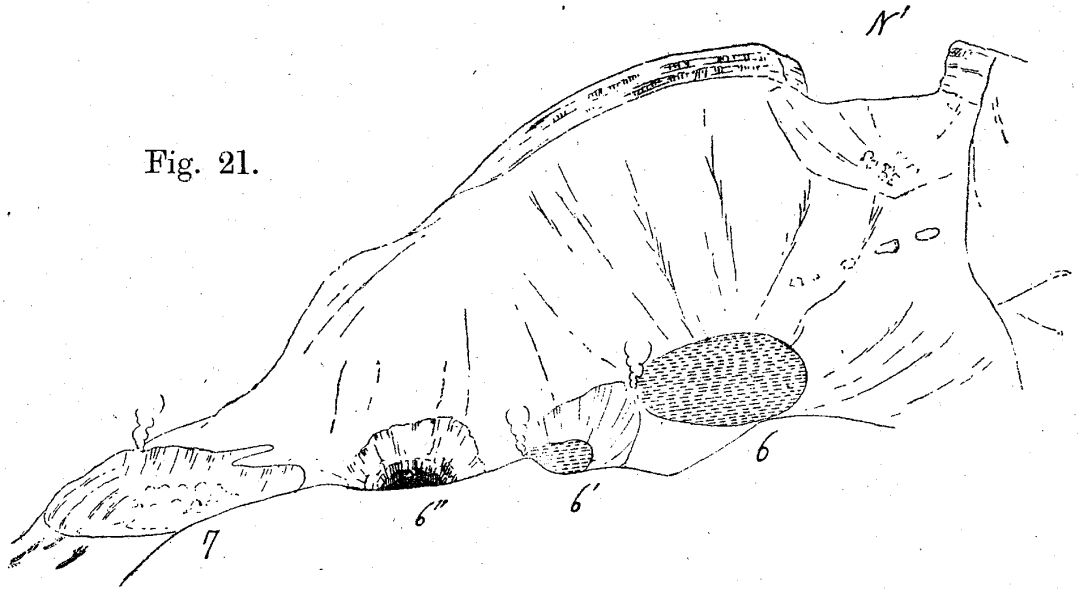



Fig. 21.




Figs. 20 and 21. Sketches illustrating the Arrangement of the Craterlets in the Eastern Portion of the Nabe-yama Eruption Crack. (May 3, 1915.)
6, 6', 6'', and 7.....Craterlets Nos. 6, 6', 6'', and 7 respectively.
N'.....Highest part (opening) of the Nabe-yama Eruption Crack.

diameter, formed out of the soft clayey or ashy material of Nabe-yama, the bottom being plane and filled with ashes and some water. It looked like the No. 4 craterlet already mentioned, and indicated no rock exposure on its inner conical side. Immediately below and continuous to this large hole, there is the small craterlet, No. 6′, about 20 m in diameter. At a slightly lower level, there is another small hole, the craterlet No. 6″. Separated from the lower end of the latter by an accumulation of lava masses, there is the craterlet, No. 7, an oblong elliptical cavity, about 60 m in width and 100 m in length, which extends within the height limits of 185 and 140 m above sea-level, and whose top layer has foundered, as is the case with the lava source below the No. 4 craterlet. At the upper end, there is a nearly circular opening more or less clearly separated from the rest of the craterlet bottom; this being evidently an orifice from which the new molten black lava flowed out, part of which still remains piled up outside the upper edge. The lower end of the craterlet, which looks like a dry dock, is blocked up by the successive layers of black solidified lava masses, outside which there expands the extensive lava fields on the Krokami side. (See the sketches in figs. 20 and 21, and the photograph in fig. 102.)

At the time of the present author's visit to these parts, on May 4th, 1915, the different craterlets were completely quiet, only slight columns of smokes rising from the upper and lower edges of No. 6′ and from the side edges of No. 7. Yet all along the slope forming the N. side of the Eruption Crack, the ground was hot, over 100° C in temperature, and series of solfataras were issuing along the entire margins.

**4. Remarks on Nabe-yama eruption crack.** At the east or highest boundary end of the W. portion of the Nabe-yama Eruption

Crack, below which lies the deep eastern portion, the two banks or sides form a sort of strait or gate opening, pq in figs. 24 and 25. (See also the photographs, figs. 77, 87, and 88.) The height of the two cliffs p and q is each about 12 m, while the width of the

Fig. 22.

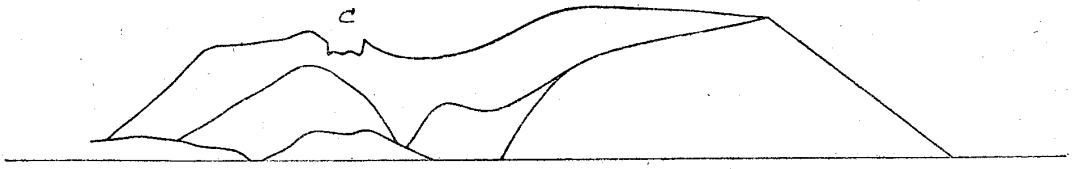



Fig. 23.

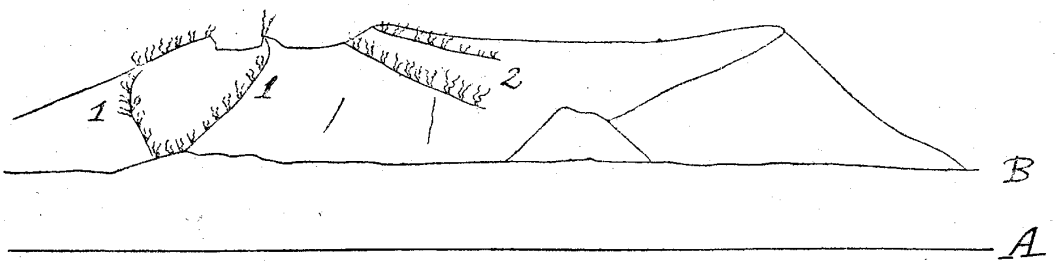



Fig. 24.

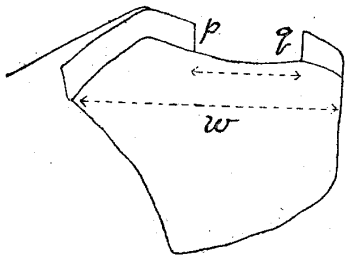



Fig. 25.

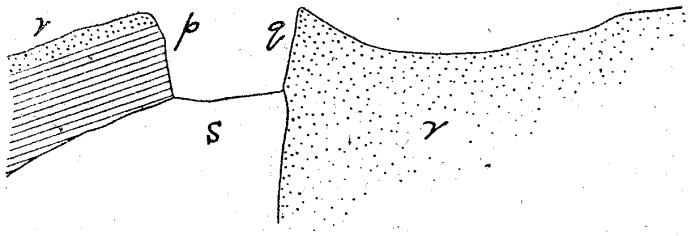



Fig. 22. Outline of Nabe-yama seen from East.
C = Top opening of Eruption Crack.

Fig. 23. Nabe-yama seen from East, showing the issue of small steam columns along the mouth boundary (1) of the eastern portion of Eruption Crack, and also along other fissures (2). (May 4, 1915.)
A = Sea-level. B = Plateau at base of Nabe-yama.

Fig. 24. Eastern Portion of Nabe-yama Eruption Crack seen from the front.
Width w = 100 m. p, q = Exposed edges of the lava layer.

Fig. 25. The Top Opening of Nabe-yama Eruption Crack, seen from East.
r = Lava layer covered by ashes. s = Bottom of Eruption Crack.

opening pq (fig. 24) is about 60 m. The margins of the eastern portion of the crack indicate an additional covering, which had at places yellowish incrustations, and along which smokes were everywhere issuing slightly. (See figs. 23 and 88.) This new layer, masked under the thick surface accumulation of ashes and rock fragments, seems to be nothing other than the coating formed by the lava which flowed over from the large craterlets Nos. 2 to 5 on the other side of the Eruption Crack, and of which a portion poured down into the central hollow space of Nabe-yama. The topmost opening pq is therefore not the result of an excavation, but in reality only a space formed by the exploding away of a portion of the new lava sheet.

The southern flank of Nabe-yama is dislocated at two different heights, giving out white smokes from numerous points situated along the crack lines. These steps are evidently the terminal sides of the sheets of lava outflow which were successively issued in the earlier stage of the eruption, probably from the craterlets Nos. 2, 3, 4, 5, and 6.

**5. Lava pieces projected from eastern craterlets Nos. 3 and 4.** Between the No. 2 and No. 3 craterlets there is no apparent direct canal communication, but the ground is much fissured, giving out sulphurous gases of strong and almost choking smell. The ground is thickly covered with dark gray angular lava blocks of various dimensions, as is the case with the higher portions of Asama-yama, there being not a small quantity of loose slaggy lavas of yellowish colour like those projected from the latter volcano on the occasion of the long-continued eruption on Oct. 2nd, 1911. There are also numerous flattened and partly crushed lava pieces of dark and slightly yellowish colours which resulted from the impact against the ground of the red-hot masses projected

in plastic condition from the craterlets. A huge block of this sort measured about 41 feet or $12\frac{1}{2}$ m in length. Of the lava pieces projected out from the craterlet No. 3, a considerable proportion is deep red in colour, a fact limited to this neighbourhood.

On the slope ground to the south of the Eruption Fissure connecting the craterlets Nos. 3 and 4′, the loose blocks, several of which are large, are also very numerous; one of these, shown in fig. 41, is 2 m in height and $5\frac{1}{2}$ m in length, and has the shape of a crushed onion root. That these semi-breadcrust bombs, thrown out in the later stage of the eruption, are the results of comparatively feeble explosions, may be inferred from their small range of projection, which was limited to the distance of about 450 m from the south wall of the Eruption Fissure or the top of the slope in question. Further down the latter there are only hard lava fragments. The slope had first been covered by the lava outflow in the early stage of the eruption, the lower portion being thickly coated with ashes. For the upper 500 m of the slope, the ash layer was again buried under the volcanic sands of subsequent issue which were at the end of April, 1915, still so hot at several places as to render it impossible for us to stand there for a long time, due probably to the preservation of heat in the lava mass beneath. At one instance the sand temperature at 1 foot depth was 86°.3 C, while the simultaneous air temperature was 14.°2 C. Along crack lines, where slight fumaroles were issuing, the soil temperature was still higher. The reddish and black lava pieces found in these parts were not covered by ashes or sands, having been projected out at much later date. On the top of the same slope there remains a layer of lava, (*a* in fig. 26), about 3 m in thickness and 50 m in the downward extension; this being the

remnant of the last overflow of the molten mass from the Eruption Fissure. (See the photograph in fig. 43.)

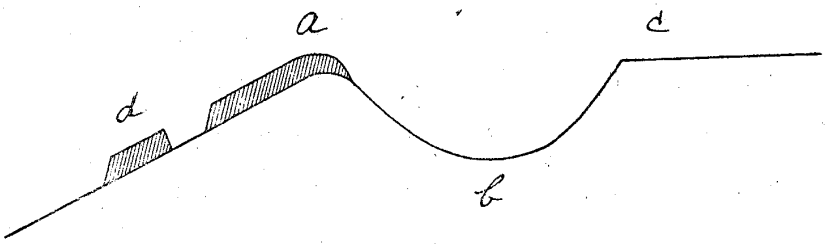



Fig. 26. Section illustrating the overflow of lava (a, d) from the Eruption Fissure (a b c).
d.....Length=5m; thickness=2m.

*Remarks on plastic bombs.* The "plastic bombs" seem to have characterized the last stage in the present Sakura-jima eruptions, when the magma at the bottom of the craterlets was no more pumiceous, that is to say, ceased to give out powerful jets of gases and steam, while the surface cooling was comparatively quick. In the case of Asama-yama, the projection of similar plastic bombs and lava fragments on the occasion of the long-continued outbursts on Oct. 2nd, 1912, marked the last as well as the first stage in its recent eruptive epoch, when the lava tended to flow out of the crater; the bottom of the latter having been elevated on that occasion almost to the brink.

**6. Craterlets on western side.** As remarked before, the No. 1 or highest craterlet is the only explosion cavity of perfect form existing on the western eruption field.

*No. 1 craterlet.* This has been formed inside the S. limb of a large U-shaped valley, evidently the site of an old explosion crater, which lies to the N. of Hikinohira and which opens westwards. The rim of the craterlet, whose height is 79 m and whose inside wall has an inclination angle of about 56°, is highest at the S.E.

and lowest at the W. side; the diameters of the mouth and the bottom being respectively about 174 and 63 m. The earlier stage of the outbursts here might possibly have been due to the formation of a number of small and shallow secondary explosion openings; a portion of one of these latter still remaining exposed to view at the top of the E. side wall of the craterlet. (See figs. 49 and 74.) As may be expected from the proximity of the heat

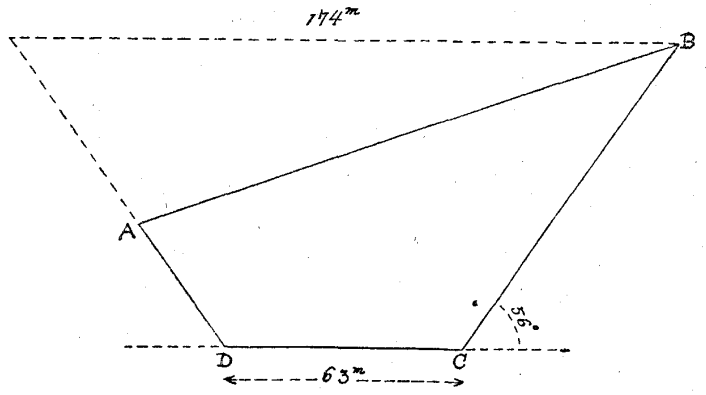



Fig. 27. NW-SE Section of the W. Side Craterlet No. 1.
Height differance, between B and C=79 m.

area and the local lava reservoir mentioned in § 7, the large craterlet under consideration is exhibiting the residual activity in the form of numerous fumaroles, of which those near the Hikino-hira or S.E. side were specially energetic and had hissing sounds, the temperature being over 90° C in April-May, 1915. The whole bottom area, parched and not much buried with pumice, was then still very hot and there were more than one dozen of small shallow conical holes, of 4 m diameter and of 1 m depth in maximum size, many of which were dry and gave out steam and gases with a strong smell like that of vinegar. These had been formed probably by powerful emissions or miniature explosions of gas after the cessation of the stage of the principal outbursts and possibly later than the 20th of Jan., 1914. There were also fumaroles on the western inside slope of the craterlet, the

temperature measured on April 30th, 1914, being 88°.6 C. It may be remarked that the upper lip of the craterlet is 570 m above sea-level, or 135 m higher than that of the completely extinct No. 1 craterlet on the eastern or Nabe-yama side.

The ejecta from the craterlet seem to have been thrown mainly toward the W. where the wall is lowest, there being a great accumulation of hard lava blocks more or less in the form of bread-crust bombs, some of which are several metres in dimension. (See fig. 40.)

The western craterlet No. 1 is, in point of size, and was also probably in the violence of the explosion, inferior to none of the eastern craterlets, which latter indicate no trace of the "conical holes" at their bottom. It may be regarded as being equivalent to an explosive craterlet combined to an "eruption chimney", or the highest opening only for the emission of smokes which has been formed separately on the eastern eruption field (§ 2).

*Lower craterlets series.* The series of the lower craterlets (No. 4 in fig. 3, Pl. XXXIII.) forms a straight zone in the E.S.E. and W.N.W. direction, more than 400 m in length, along which have been formed amongst the others 4 more or less distinct shallow explosion holes. (See fig. 54.) The latter, of which the uppermost is the largest, are situated at heights of 100 to 160 m above sea-level, at a distance of about 400 m or more from the northern boundary of the lava area in these parts.

**7. Lava sources.** On the eastern eruption field there have been formed, besides the regular craterlets, in two cases also some fissures or orifices constituting the sources from which the molten mass flowed out continuously for some time interval. At one of these found immediately below the No. 4 craterlet at 220 m above sea-level, the latest and solidified lava issue of black colour

remained in its position forming a sort of large elongated U-shaped mound, about 20 m in height, 50 m in width, and 150 m in length, which looks from side like a flat lava cone. (See the sketches in fig. 28 and the photograph in fig. 100.) The U,

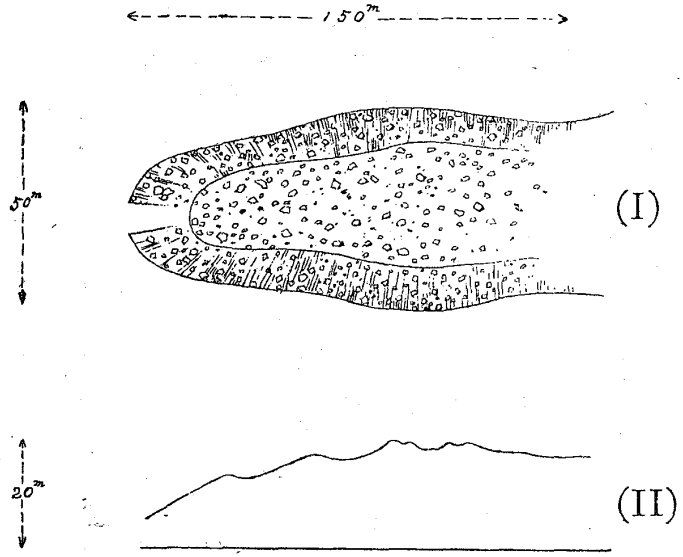



Fig. 28.
Lava Source below the Eastern No. 4′ Craterlet.

I.....Plan.
II.....Side outline.

whose two limbs expand in the lower plane into an extensive fan-shaped lava field, had originally been an arched or vaulted grotto-like passage, whose roof crust along the central axis fell down, leaving on both sides traces of the springer formation more or less clearly. At the upper end of the mound in question there is exposed to view a small arched hole, this being the orifice of a shaft probably leading down to the lava reservoir under Nabeyama Eruption Crack.

On the western field of eruption, a typical massive and elongated lava source (figs. 51 and 52) remains in a well-preserved condition at a height of about 350 m above sea-level, 1 km to the N.W. of Hikinohira, and at the S.W. base of the 400 m hill above the village of Akobaru. When seen in April 1914, the outer curved layers of the lava crust were found partly peeled off at the

top so as to resemble, in front or back view, somewhat a half-opened lotus flower in form.[1] During the active stage of the eruption, the mass of magma had been forced up there as well as at other points in the vicinity such that the ground above these lava sources must have suffered highly characteristic disturbances. Thus the small radial hill ridge forming the N. limit of the U-shaped valley, which opens westwards and in which the No. 1 craterlet is situated, has been much torn by longitudinal cracks and also by transverse ones; the latter being accompanied by successive stepwise dislocations, so as to present in a distant view an arrangement somewhat like the stripes on a tiger's back. (See figs. 50 and 29.) The lower end of this "lava head" is excessively broken up and becomes continuous with the actual lava source of the No. 2 vent. The whole hill ridge, almost from its upper end, or the junction with the top slope of Kita-dake, was giving out from different points small feeble columns of bluish-white fumes; the ground, which is parched and covered here and there with white or yellowish incrustations, causing much flickering of the air and having a high soil temperature of 90° to 100° C. The latter circumstances must indicate the existence at a shallow depth of the red-hot lava mass, as has been actually found out by the present author at the 3rd visit to Sakura-jima, in April-May, 1915.

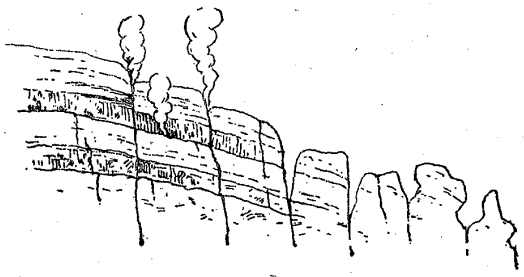


Fig. 29.

Side view diagram illustrating the successive stepwise dislocations of the ground immediately above the western lava source No. 2.

(1) When visited in Sept. 1914, the thin outspreading parts of the lava source were found much broken down.

Thus at a point within the spot in question, 551 m above sea-level, the surface crustal portion had fallen in, forming an oblong cavity of mouth diameters of 15 and 8 feet, and extending obliquely to a depth of about 12 ft. At the bottom of the vault, continued to a sort of tunnel, evidently expanding toward the downslope, there was exposed to view a glowing red-hot surface of lava in the form of a semi-circle 5 ft in diameter, probably continued some distance into the passage. Small hard rock pieces, a few inches in dimension, thrown on the bright molten lava surface were turned into the same heated condition in the course of a few minutes, while pieces of wood were instantly set on fire even when thrown on the dark-red solidified part on the bottom in front of the molten mass. As the latter was perfectly stationary, it is evident that here we have to do with a case of a local lava reservoir, which is in a remarkable way situated at a height of 59 m over the bottom level of the craterlet No. 1, and which has preserved the fluid condition more than 1 year after the eruption. At the same time it is likely that a similar underground heat condition prevails in the neighbourhoods of the different craterlets on the western and eastern sides of Sakura-jima.

The cracking accompanied by the successive stepwise dislocations of a hill side may be partly the effects of an enormous underground expansive action or upward pressure (fig. 30) which has

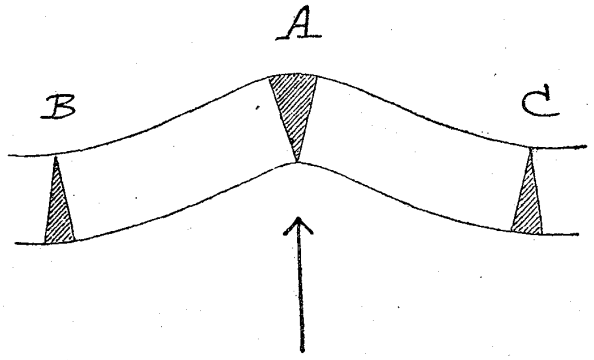



Fig. 30.

Sectional diagram showing the effect of the upward action of the underground lava mass.

A.....Open crack on ridge.
B, C.....Fracture at valley parts.

even obliterated the existence of a narrow valley some 50 m in depth, formerly situated at the N. base of the above-mentioned hill ridge. Several of the small valleys in the higher part of Minami-dake (and also of the other two peaks) may be, not the results of mere erosions, but the sites of explosive craters or eruptive fissures formed ages ago. Again, it may be stated in connection with the origin of the elevated parts that the ridge to the S.E. of the 400 m hill immediately to the N. of the western No. 3 vent (lava source) has been in the recent eruption much torn by longitudinal and other cracks, which emitted hot fumes of strongly pungent smell. The absence of similar traces of disturbance at the base of the ridge seems to indicate that the latter was originally an upheaval formed by the upward pressure exercised by the magma at some former activity epochs of the volcano.[1] The top of the 360 m hill, extending in the N.-S. direction, which is situated to the W. of the above-referred 400 m hill, has also been much cracked by deep fissures pointing toward the centre of the island. These gave out vapours and are 1 to 2 feet in width, reaching down vertically 12 feet or so; but the real depth, which must be much greater, could not be ascertained, as the bottom has been filled up with fallen rock fragments.

**8. Secondary craterlets.** Apart from the western eruption field there were discovered by the present author on April 8th, 1914, two small secondary craterlets on the slope of the upper part of a narrow valley leading up from the village of Take (武) at an altitude of about 370 m, namely, at a distance of 1.0 km to the N. 25° W. of the centre of the No. 1 craterlet. (The position is

(1) In the case of the Usu eruption of 1910, six small explosion craterlets were formed on the top of Nishi-Maruyama, a low round elevation, but none on the plane ground at its foot. This was probably due to the circumstance of the formation of the hill being similar to that supposed to be the case in Sakura-jima.

**Sakura jima Eruption of 1914 : Pumice layer floating on sea surface.**

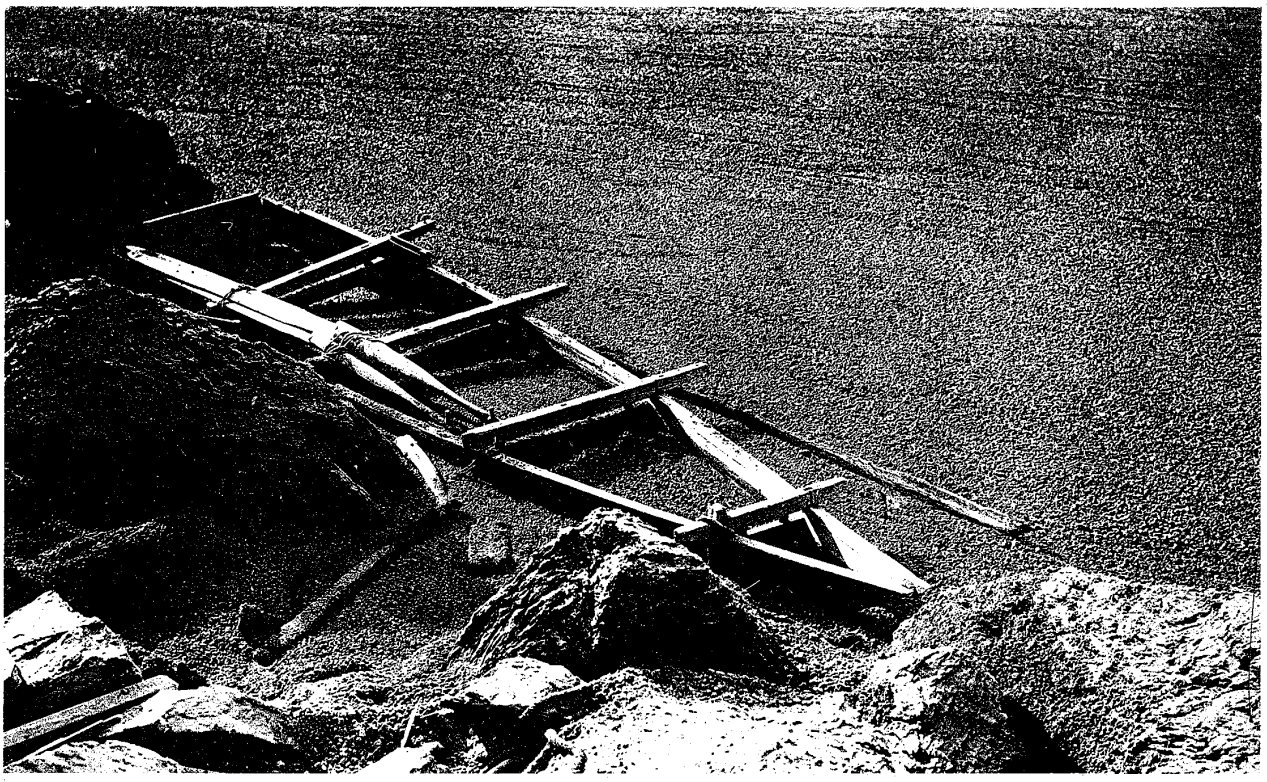


**Fig. 34.** A boat nearly submerged in the floating pumice layer at Koike on the W. coast of Sakura-jima. (Yuki, photo.)

**Fig. 35.** Floating Pumice Layer outside the Harbour of Kagoshima. The precipitation of ashes rendered the torpedo-boat destroyer Shiratsuyu at a near distance dimly discernible. (Jan. 19th, 1914. F. Omori, photo.)

**Sakura-jima Eruption of 1914.**

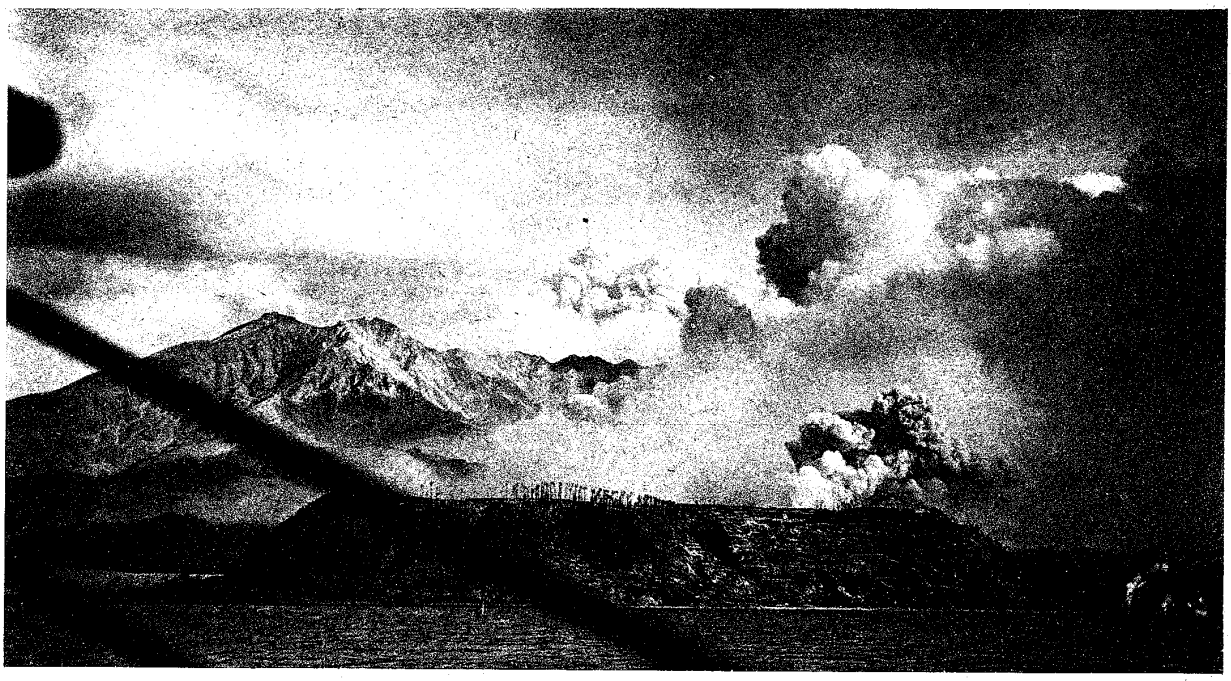


**Fig. 36.** W. side view of Sakura-jima taken while sailing in Kagoshima Strait on board the steamer *Nishiki-maru*, with the trapezium platform of Hakamagoshi at the front. (Jan. 19th, 1914. F. Omori, photo.)

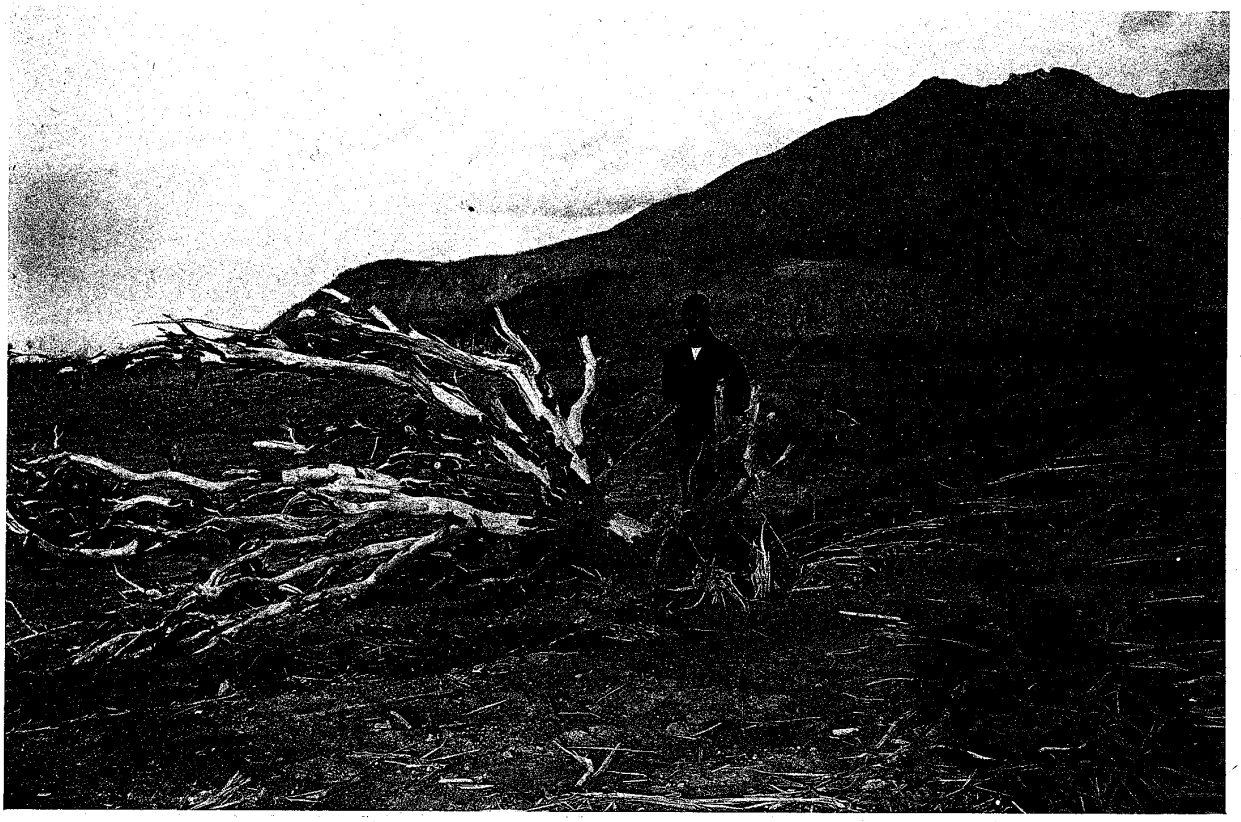


**Fig. 37.** W. side of Sakura-jima seen from the top of Hakamagoshi, indicating a large mandarine-orange tree uprooted and carried from the village ground below to the plateau by the force of the Eruption Blasts. (April, 1914. F. Omori, photo.)

**Sakura jima Eruption of 1914 : Thick Accumulation of Ashes in the E. part of Sakura-jima.**

**Fig. 38.** Houses at Krokami buried in ashes. (March 16th, 1914. F. A. Perrett, photo.)

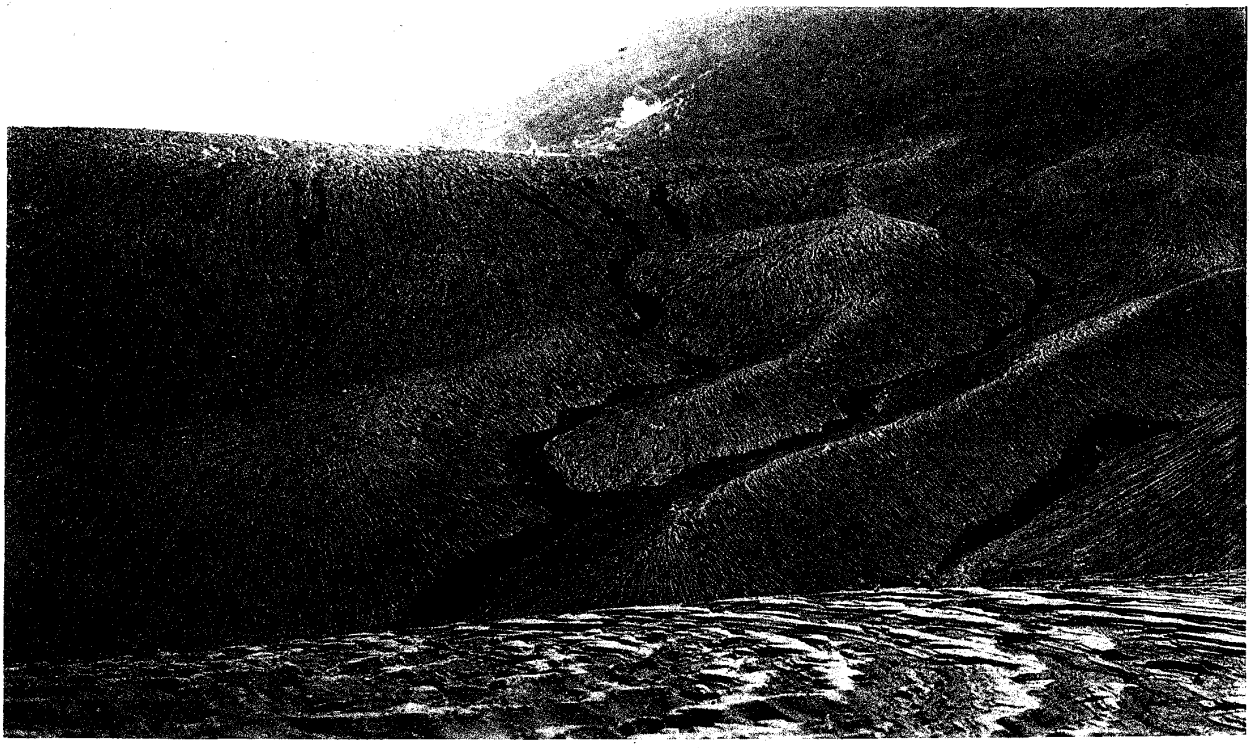


**Fig. 39.** Slope ground to the N.W. of Nabe-yama, seen from Gongen-yama, indicating the new layer of ashes cut into fine grooves by rain. (April, 1915. F. Omori, photo.)

**Lava masses projected in semi-plastic state in the later stage of the Eruption of 1914.**
(April 1915. F. Omori, photo.)

**Fig. 40.** Condition at the bottom of the Western No. 1 Craterlet.

**Fig. 41.** A large flat crushed lava disc found on the slope forming the S. side of the Eruption Fissure connecting the Eastern Craterlets Nos. 3 and 4'.

**Lava masses projected in the later stage of the Eruption of 1914.** (April, 1915. F. Omori, photo.)

**Fig. 42.** A large bread-crust bomb found at the S. rim of the Eastern Craterlet No. 2.

**Fig. 43.** Platy projection or overflow on the sloping S. side rim of the Eruption Fissure connecting the Eastern Craterlets Nos. 3 and 4.

indicated by two small red dots in the map, Pl. IX, of the preceding Number of the Bulletin.) One of these, on the lower level, shown in fig. 48, is about 8 and 9 m in diameters and filled with reddish slaggy lava masses. Whether the latter had been forced up during the recent eruption or not, was not easy to decide. But the occurrence of a sort of miniature eruption from the hole in question, probably after the principal eruptive epoch, was indicated along the rim by the accumulation to a thickness of several inches of gray ashes, which presented a fresh appearance on the above-mentioned date; the temperature of the pumice layer around the mouth being also high and over 130° C. The two secondary craterlets together with a number of feeble steam issues were arranged along two nearly horizontal U-shaped crack lines, about 150 m in longitudinal extension. When visited again in September of the same year the holes were much filled up and indicated no heat phenomenon, the fumaroles in the vicinity having also disappeared. According to the accounts of Messrs. Ueda and Yamaguchi, of the Kagoshima Girls' Normal School, there has been in the ravine at the S.E. base of Hikinohira a slight outflow of lava apparently due to the recent eruption.

*Ebinotsuka.* Ebinotsuka is a beautifully-preserved small old ash and pumice cone of unknown date of formation, rising to the height of 122 m, and situated just outside the lava area on the plateau about 50 m above sea-level to the S.W. of the village of Krokami and approximately to the N.E. of Nabe-yama. The top ridge of the crater-wall, whose mouth diameter is 80 m and whose opening is directed toward the S.S.E., is much cracked and, when observed on Oct. 2nd 1914, issued feebly gases and steam. Amongst the others, there were several well-like depressions, from which some steam was rising. The greatest of

these had a diameter of 3 m and the depth of not less than 6 m. It is probable that the recent great eruption produced fissures and other underground or surface disturbances in the region neighbouring the new actual craterlets.

**9. Depression cavity.** The level of the molten lava, which is pushed up in a volcanic conduit during the activity of eruption

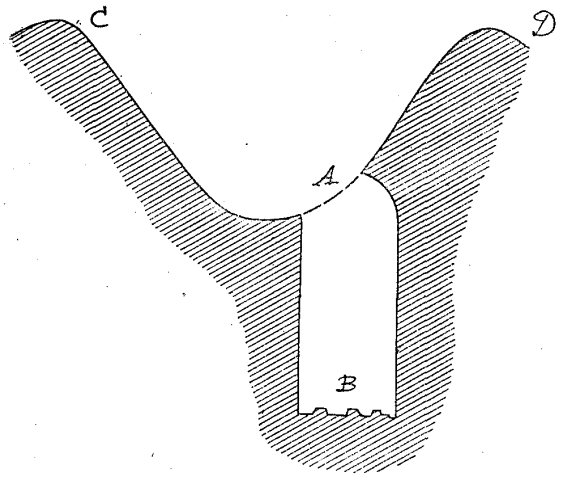



Fig. 31.

Depression Cavity at the Bottom of the Craterlet No. 6″ in the Eastern Portion of the Nabe-yama Eruption Crack.

C, D.....Respectively the N. and S. edges of the eruption crack.

A, B.....Top and bottom of the depression cavity.

phenomena, necessarily settles down with the decline of the latter. In a large open crater, like that of Asama-yama or of Ō-shima (Izu), the depression of the central portion of the extensive bottom leaves behind in this way an annular portion or terrace along the circumference. If the conduit be narrow the depression may result in the formation of a sort of hollow well or shaft, whose top may or may not be exposed to view. In the case of the recent Sakura-jima eruption, the depression cavities were formed on the eastern eruption field in the craterlet No. 6″, in the craterlet No. 4, and at the lava source below the latter.

The inside roof of the vertical cavity, about 15 m in diameter, formed at the bottom of the craterlet No. 6″, which was partly visible from the north edge of the Nabe-yama Eruption Crack, constitutes a sort of vault with great many short, and more or less columnar, lava

projections hunging down from it (fig. 101). Small rock fragments thrown, by way of experiment, horizontally from the edge (C, fig. 31), reached the floor A in 3.0 sec., while others similarly thrown required 4.5 sec. in reaching the invisible shaft bottom B, the arrival thereon being indicated by the sound of impact. Estimating from these time observations, with suitable correction on the effect of the air resistance, the depth AB of the shaft is found to be about 40 m. A vertical lava hole about 10 m in diameter (and, when seen in April 1914, some 20 m in depth) formed close to the lower rim of the eastern No. 1 craterlet may also be the result of a similar depression process.

The depression cavity formed at the bottom of the eastern No. 4 craterlet, which is highly characteristic, has been discovered first at my visit there on Sept. 22nd, 1915. At the time of my previous trip, on April 23rd, in the same year, there was at the craterlet bottom a small mass of lava which had an appearance of the accumulation of loose fragments fallen from the side wall. (See fig. 91.) In reality, however, this was a protuberance of the molten lava out of the conduit below, being the result of the last eruptive effort of the magma, probably at the end of 1914, when the latter could no longer be projected up into the air. The lava mass in question had probably been already cracked vertically about or some time before April 1915, as a series of small dust explosions took place from the craterlet No. 4 on May 5th of the same year. (See § 21.) The cracking might possibly have been actually formed on that occasion. The final result was the subsidence of the whole N. vertical half of the lava mass, the section exposing to view a sort of compact inner column tapering upwards, some 30 m in height and supported by a beautiful spherical vault, about 15 m in diameter. (See the photograph,

fig. 99.) In the dark bottom space could be seen another inside roofing with dislocations at top, this probably forming a sort of tunnel whose lower end was in communication with the lava source below the No. 4′ craterlet.

The roof of a depression lava cavity, in case it remains unbroken, may be more or less spherical. Thus, if AB (fig. 32)

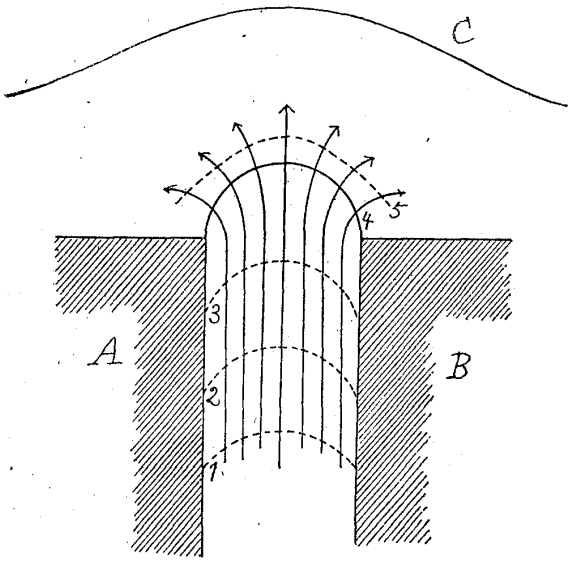



Fig. 32. Sectional Diagram illustrating the formation of an Internal Depression Cavity with Vaulted Roof.
C.....Lava surface. Arrows indicate the direction of lava flow.

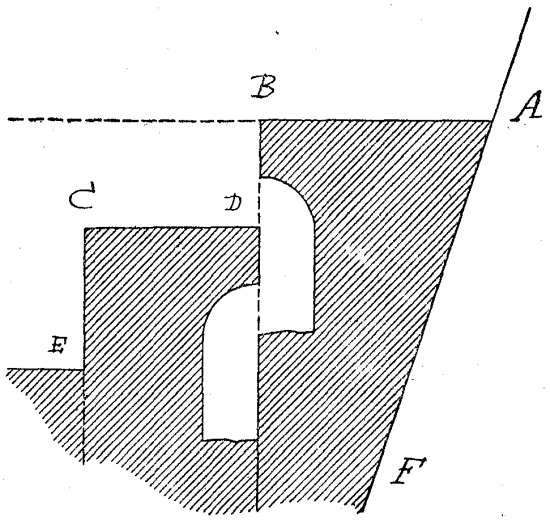



Fig. 33. A Diametral Section of a circular Crater filled with molten lava.
AB.....Level reached by the molten lava.
AF.....Crater wall.
B,C,.....Places of successive dislocations, resulting in level depressions D,E,.....
D.....Depression cavity.

represents a volcanic conduit, the fluid magma will be forced up in a series of front surfaces 1,2,3,4,5,.....; the portion 4–5, cracked into a number of separate blocks, forming an arch or a vault, which remains behind, if sufficiently strong, after the lava mass in the conduit have sunk. In the case of a general depression of the central portion of the lava area filling a large crater bottom (AB..., fig. 33), a series of the cavities may be formed along the dislocation boundary B,C,... exposing to view the back-side half of a cave

or vault, D, E, ..... This is exactly what took place in the crater of the Ō-shima volcano after the eruptions in 1912.

**10. Amount of depression of lava level.** (*A*) *Eastern lava field.* In the eastern portion of the Nabe-yama Eruption Crack, the lowest rim and the bottom of the craterlet No. 7 are respectively about 140 and 110 m above sea-level. The level of the mouth of the depression cavity of the craterlet No. 6″ is 160 m, while that of its bottom was, in Sept. 1915, about 120 m. Again, the bottom of the craterlet No. 4 is at a level of 250 m, the lava surface under it having been depressed several dozen metres further down. The lava source below the last mentioned craterlet is at a height of about 220 m, the bottom of its tunnel or shaft being further down. As the height of the uppermost limit of the lava overflow about the No. 1 craterlet is 430 m, it follows that the surface of the magma under the volcano elevated to the latter level at the commencement of the eruption has been lowered after its conclusion probably to a height of 110 m, or through a vertical distance of 320 m. In Sept. and Oct., 1914, when the craterlets Nos. 3 and 4 still maintained the firework-like eruptions of lava, the level of the latter was probably kept at a height of some 250 m above sea-level. (*B*) *Western lava field.* The uppermost lava sources were formed at heights of 400 to 500 m, while the lowest craterlets were at heights of only about 65 m; the vertical distance difference amounting here also to more than 335 m. It thus seems that on the whole the magma was upheaved during the eruption, in round number, some 350 m over the final depressed level of its crustal surface, the actual top of the inside molten lava being probably some distance further below. Hence it would be no exaggeration to suppose the total amount of the depression of the lava level after the eruption to be 500 m. In other words, the

molten lava mass under the Minami-dake crater exists at ordinary times probably at the depth corresponding to the sea-level.

By way of examples, it may be noted that after the great Asama-yama eruption of 1783, when the "Oni-oshidashi" lava flowed out over the N. rim of the central crater (diameter=400 m) the bottom of the latter has sunk to a depth of some 300 m. Again, after the Ō-shima eruption of 1777, when an enormous amount of lava flowed out of the central crater (diameter=600 m), the bottom has subsided some 120 m.

**11. Process of eruption.** The majority of earthquakes which occurred in Sakura-jima previous to, and during, the recent eruption were probably the results of creating or enlarging the zone of volcanic fracture, in the way of preparation for the ensuing outbursts. The premonitory explosion at 8 a.m. on Jan. 12th, 1914, when a column of white vapour was projected up from the Minami-dake crater, may possibly denote the completion of the upper extension of the underground plane of disturbance. At the same time it is likely that there are a number of old fissures or narrow communications in the filled up conduit of Minami-dake, as is evinced by the existence of fumaroles inside and outside the top walls; it being not necessary to suppose that the new inside fracture reached up to the bottom of the crater.

The greater amount of lava outflow from, as well as the longer duration of the activity of, the eastern side craterlets is probably to be attributed to a greater width of the fracture zone in that direction; this supposition being apparently supported by the fact that there exists on the east side the broad Eruption Canal between the craterlets Nos. 2, 3, and 4, and also by the formation of the remarkable Nabe-yama Eruption Crack. Mr. Perret maintains that the speedy extinction of the eruptive

disturbances on the west side was due to the formation of the lower craterlets along a valley region, whereby their mouths must have been blocked up by the lava streams flowing down from the higher levels. Similar effects, however, must have taken place to a certain extent also at the east side in the case of the No. 2 craterlet and with those openings in the E. and W. branches of the Nabeyama Eruption Crack. On the whole, it looks probable that in the present instance the eruptive activity was really greater along the E. than along the W. side craterlets zone.

As will be seen from figs. 2 and 3, the highest explosive vents were formed on both flanks of Minami-dake a little below its half height, namely, about the lower boundary of the upper and steeper portion of the mountain which is nearly symmetrical with respect to the N.–S. direction. The upper boundary of the western eruption field is, however, 100 metres higher than that of the eastern. With this height difference might probably have been connected the apparently greater explosive violence of the initial outbursts on the western side. The existence on the eastern flank of the separate "chimney" or No. 1′ vent for steam and gases also probably contributed to reduce the explosive force of the craterlets on that side.

The greater height of the western craterlet No. 1 is evidently due to the existence of, or the coincidence in position with, an elevated ridge (I in figs. 1 and 3), which is connected with the dome-like hill of Hikinohira, and which is probably the result of an upheaval in some past epoch of the volcanic activity, it being assumed that the formation of a volcanic orifice and the forcing up of the lava take place with a greater facility under a ridge than under a valley (§ 7).