Time.	Sea-water Temperature.	Locality.
May 6th, 1915 ; from Kagoshima Harbour to Hakamagoshi, and back.		
7.20 a.m.	16.5° C (air : 18.5°)	In Harbour of Kagoshima. (Rising tide.)
7.30	16.5 (air : 15.0°)	Just within the harbour entrance.
7.35	16.7	Outside the harbour.
7.45	17.2	Middle of Kagoshima Strait.
8.00	17.2 (air : 16.0°)	„ „
8.25	17.2 (air : 16.0°)	In Kagoshima Strait, about 600 m from the lava coast.
9.15	17.5 (air : 18.0°)	Hakamagoshi beach.
4.30 p.m.	18.6 (air : 16.8°)	Mid-Strait. (Hereafter falling tide.)
4.48	18.5	Outside the harbour.
4.55	18.2	In Harbour.

Chapter VIII. Second Stage Lava Outflow.

52. 2nd stage lava flow and its median furrow. (See fig. 119, and also the map on Pl. IX. in the preceding Number of the Bulletin.) The lava streams which began to issue from the different eastern craterlets soon after the commencement of the eruption may be regarded as composing the *1st stage outflow*, and continued to move downwards or outwards with rapidly decreasing rate for about 12 months till the end of 1914. The outflow buried during this time interval the villages of Seto, Arimra, and Waki, and the whole S.E. portion of the island, the southern boundary of the area above water projecting about 850 metres beyond the former sea coast. At the end of March and the beginning of April in 1915, namely $1\frac{1}{4}$ years after the commencement of the eruption in January 1914, there took place what may be termed the *2nd stage outflow* of lava, which has been carried on quietly and, not directly

from the craterlets themselves, but from a few orifices or crevices at the southern coast of the south-eastern lava field. The new lava outflows, which were very black, in contradiction to the ash-covered and more or less weathered 1st stage lavas, expanded each

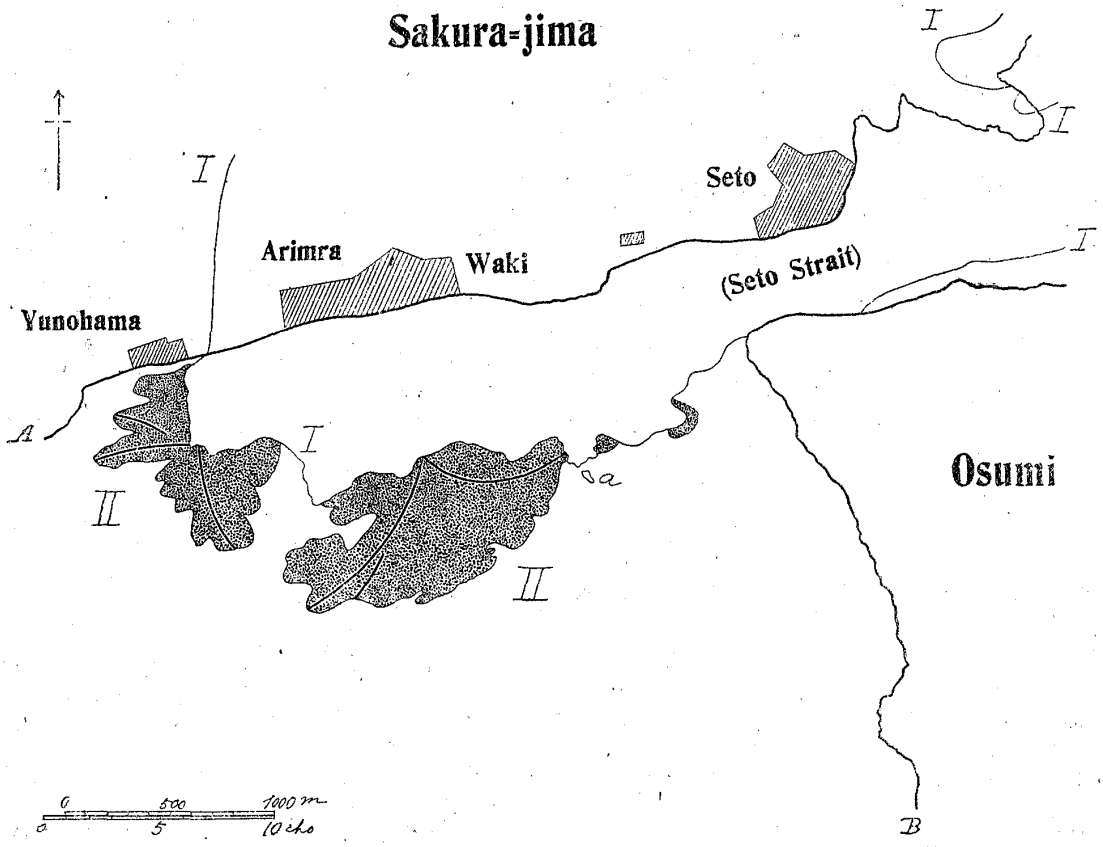
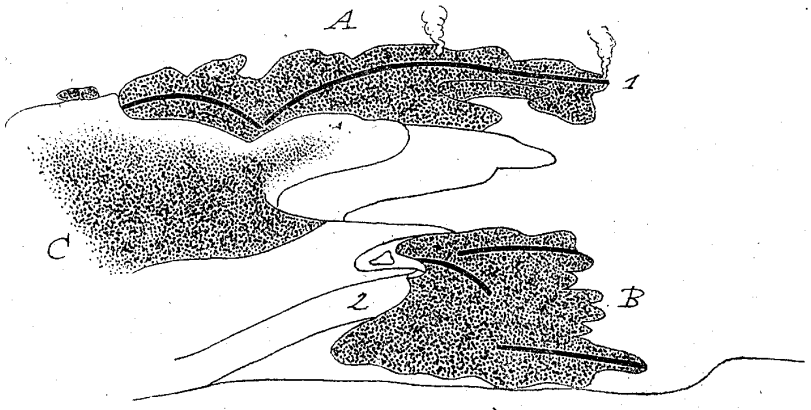


Fig. 119. Map showing the Area of the 2nd Stage Lava Outflow.
I.....Boundary of the lava area above the sea, in Dec. 1914. II.....2nd stage lava outflow.
a.....Arimra-jima, a new lava islet.

from a point source into the form somewhat like that of a chrysanthemum leaf, the greatest elongation amounting to nearly 900 m. According to the Chief Engineer Ōi, of the Kagoshima Prefecture, who inspected on April 6th, 1915, the lava field in question, the strong and almost detonative steam emission was then taking place from different points of the periphery of the latter, whose progressive displacement could be plainly observed, and which was seen during the night to send up a number of fiery columns.

A special feature of the 2nd stage outflow is the existence of a sort of *median furrow*, or a narrow groove extending along the entire middle axis of each lava protuberance. These lines, a dozen metres

Fig. 120. View from the Top of Minami-dake of the 2nd Stage Lava Outflow.



The dark portions indicate the black lavas, either (A and B) forming the 2nd stage outflows, pushed out from the side, or (C) occupying the hollow surface space of the earlier lava field.
(1).....Temporary geyser. (2).....Side moraine at Yunohama.

or more in width, could distinctly be observed with naked eye from the top of the Minami-dake, or a distance of over 4 km. (See figs. 120 and 126.) To explain their formation, let *a c b* (fig. 121) be

Diagrams showing the formation of the Median Furrow.

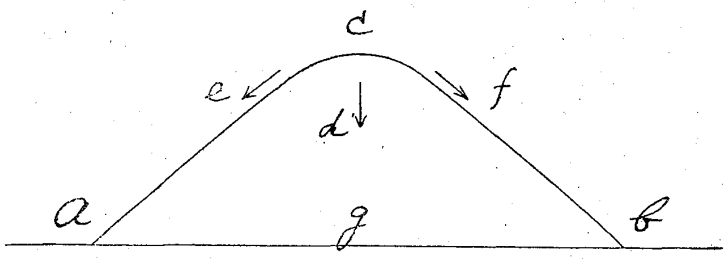


Fig. 121. Section of a lava stream, in the initial condition.

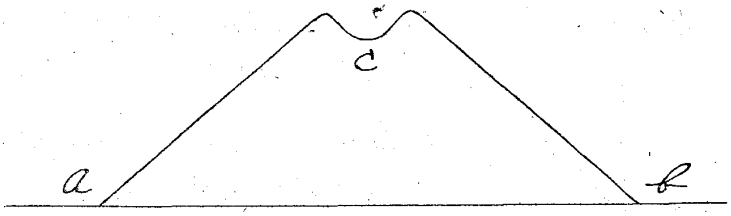


Fig. 122. Section of a lava stream, in the modified condition.

the cross section of a lava stream, the height *cg* varying from several dozen metres to over 100 m. The inside of the lava stream retains for a long time its red-hot molten condition and flows on more rapidly than the quickly solidifying surface *a c b*, causing the top portion *c* to be depressed through some distance till *d*. At the same time the lava at the ridge tends to run down the two sloping sides, as indicated by the arrows *e* and *f*. Consequently the lava stream will get a groove along its longitudinal axis, like the midrib of a plant leaf, whose two opposite sides are turned outwards. It will be noticed that the *median furrow* presents some points of similarity to the *cleavage canal* described in § 41. If the 2nd stage outflow had taken place on an inclined plane, the lava area would have been more nearly symmetrical as, for instance, is sketched in figs. 123 and 124. In the present case,

Diagrams (plans) illustrating the spreading out of the new lava area.

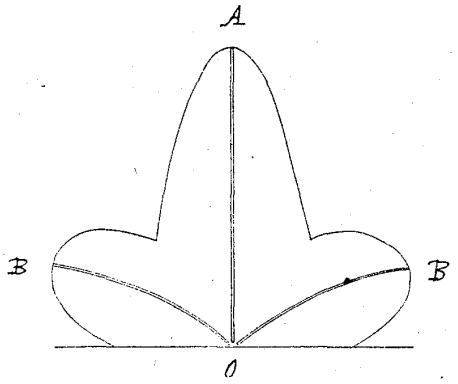


Fig. 123.

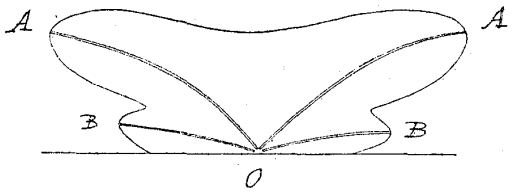


Fig. 124.

Fig. 123. Case of a single principal frontal outflow (OA), followed by two side flows (OB).
Fig. 124. Case of two principal bifurcating outflows (OA), followed by two side flows (OB).
O... Orifice.

however, the main prolongation took place in the direction of the deeper water, rendering the form one-sided.

It is hereby to be noticed that, on the south-eastern lava area, the black issues of later date filled up different points *within* the 1st stage field, sometimes occupying a hollow space of considerable

extension within the side "moraines." In these instances, however, there was no evident indication of the median furrow.

Seto "strait" lava. The Seto "strait" lava and its eastern extension show no system of well developed median furrows, the whole field forming a lengthy projection with a series of parallel longitudinal dislocation planes. At its eastern promontory end, however, there was exposed to view the cross section of a sort of a median furrow about 6 m in width and 5 m in height, as indicated in fig. 125.

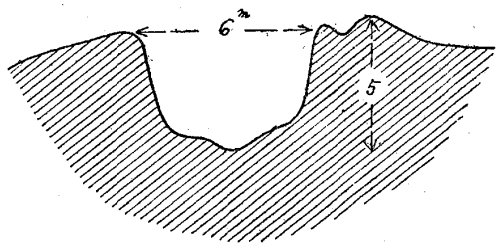


Fig. 125. Approximate section of an imperfect median furrow at the Ushine end of the Seto "strait" lava.

Western lava field. The lava mass from the western craterlets was much smaller in amount than that from the eastern ones, and flowed down into the shallow Kagoshima channel. On the western field there was no appearance of the general *2nd stage* outflow, principally on account of the comparatively small thickness of the lava mass, and of the short time interval during which the western craterlets were active. I have observed, however, at the north-western extremity of the lava area, a case of small secondary or transverse lava stream, probably formed sometime later than the main course itself, showing at the end, in the form of a cross section, a more or less well-defined median furrow whose bottom was about 2 m in width. Another case of small transverse lava stream was found at the north boundary slope of the lava field above Akobaru; the flow, which bifurcated at a distance below the outlet, having been formed at the commencement of 1915 or the end of 1914, as it had no existence at the time of my visit in October of the latter year.

The local outflow of black magma, which took place at many

points of the western lava area, was in this case due mainly, not to the continued issue from the craterlets themselves, but to the squeezing out of the internal fluid portion in consequence of the subsidence of the hardened surface layer of the main lava streams.

53. Note on old lava promontories of Sakura-jima. The beautiful form of the *2nd stage* lava area is due to the quiet and steady outflow of magma from the inside of the 1st stage lava streams, whose thickness is considerable. We may reasonably suppose that a similar process took place also in the cases of former great eruptions of Sakura-jima; the map indicating a number of the lava promontories of the form sketched in fig. 123. The Ōmoe-zaki, Nishiseko-hana, and Wariishi-zaki on the N.E. side, and the Moe-zaki and Kwannon-zaki on the S.W. side, of the island are probably due not directly to eruptions, but were each formed by a 2nd stage lava outflow several months or a couple of years after the initial strong outbursts.

54. Relation between cleavage canal and median furrow. In § 38, it has been concluded that the massive islets off the coast of Ushine moved together with, that is to say, stood on the submerged prolongation of, the lave promontory, at whose apex they had been formed. Consequently, the molten material, which formed the islets with cleavage canal must have been pushed up through orifices in the upper surface of the submerged lava stream. If, on the other hand, the lava be squeezed out freely and in a sufficient quantity, sidewise or horizontally from the solid vertical front or flank of the lava stream, there would be formed the median furrow discussed in § 52. The *cleavage canal* and the median furrow are thus to be regarded as representing the two varieties of the result of a particular process of lava outflow.

55. Geyser phenomena. At the time of my 4th visit to

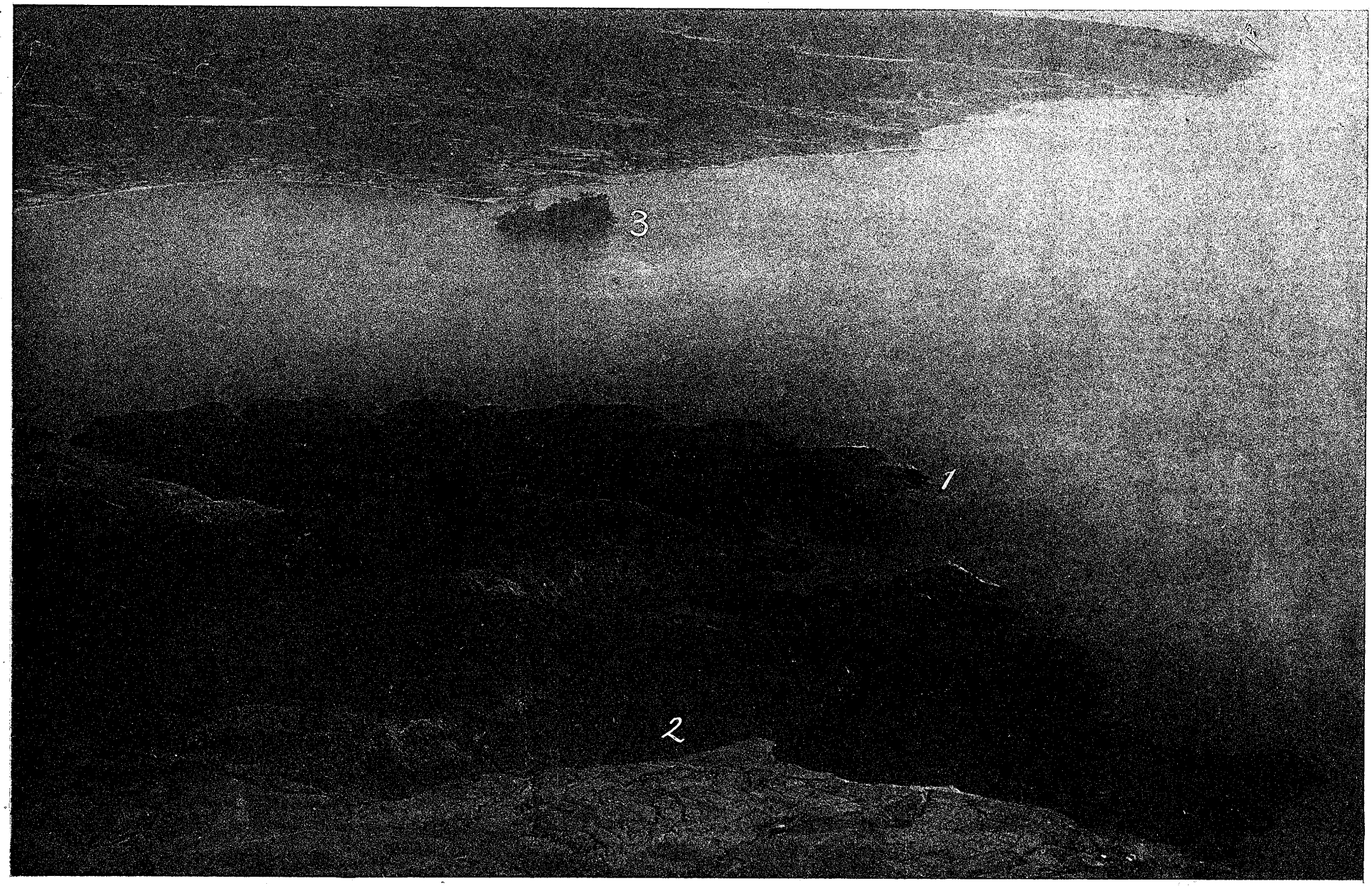


Fig. 126. View taken from the top of Minami-dake of the 2nd Stage Lava Outflow, showing the Median Furrows.
(1), Shiwofuki-zaki. (2), Side " moraine " at Yunohama. (3), Eno-shima.

Sakura-jima Eruption of 1914. (F. Omori, photo.)

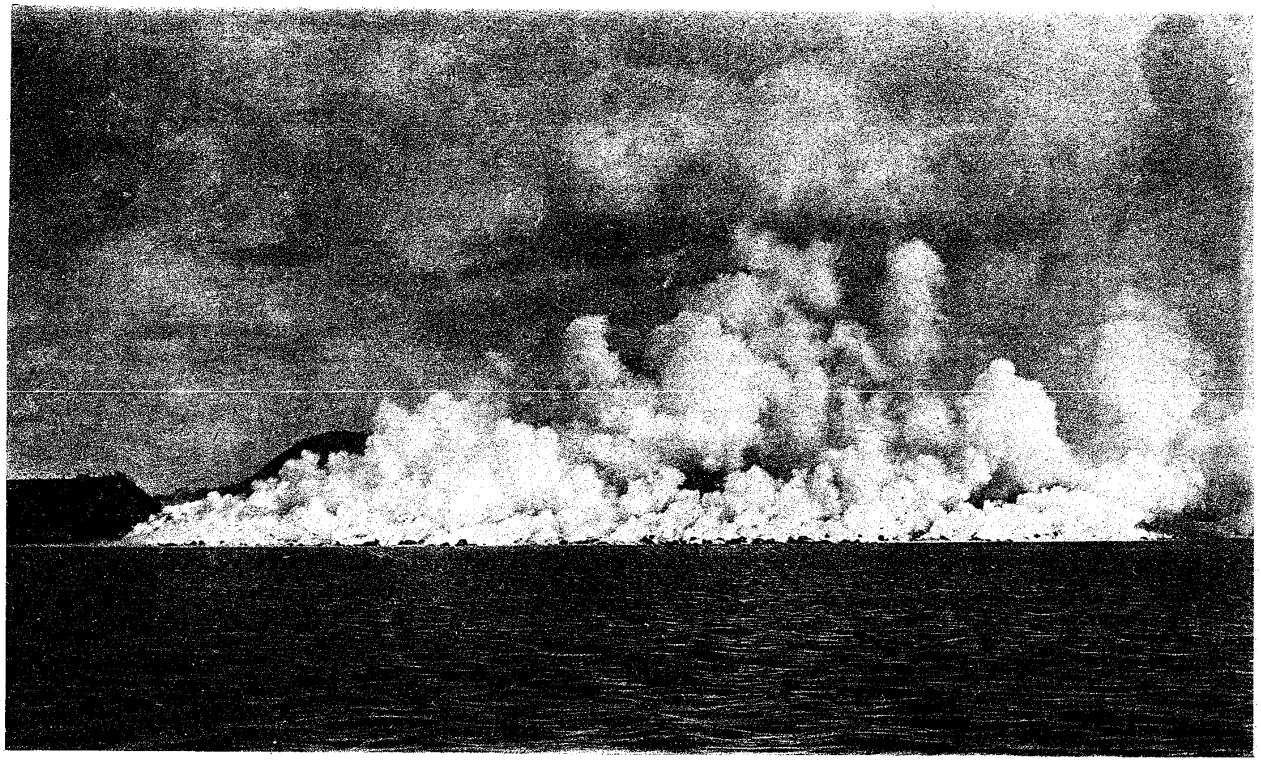


Fig. 127. Vigorous evaporation of sea-water from the lava area to the S. of Hakama-goshi (shown at the left-hand side of the figure.) (Jan. 19th, 1914.)

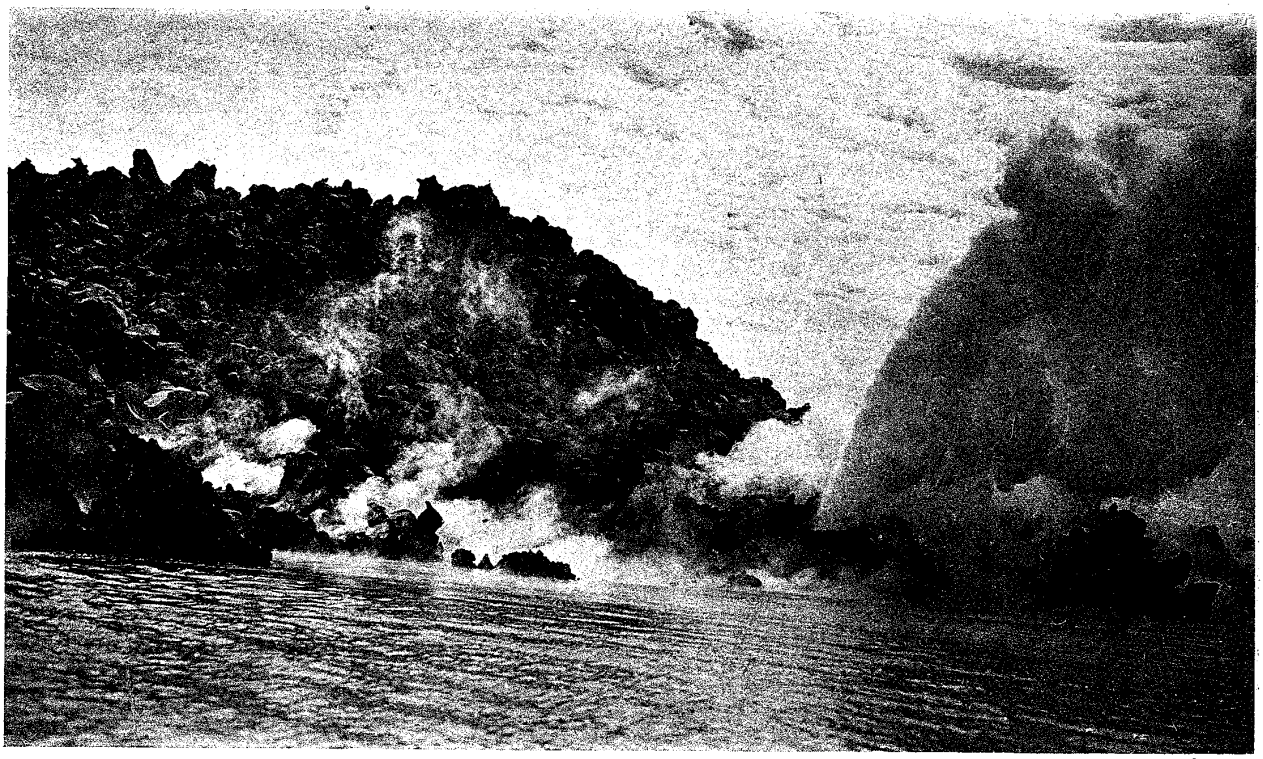


Fig. 128. Geyser produced at Shiwofuki-zaki. (April, 1815.)

Sakura-jima in April and May, 1915, small quantities of steam were feebly rising from numerous points in the eastern lava field. Amongst the others, the issue of pure white steam from the ends of the new lava protuberance extending furthest into the sea, and of the next one on the west side, of nearly equal elongation, which we have named Arimra-zaki and Shiwofuki-zaki ("water-spouting cape") respectively, were quite characteristic and frequently accompanied by loud rushing sounds like the volcanic noises emanating from the crater of Asama-yama when vigorously emitting gases and steam, or like the puffs of a locomotive when ascending a sloping ground. These lasted each time for several minutes. Thus, in one of the steam ejections from the Shiwofuki-zaki, on April 25th, 1915, the sound was heard for five min. between 7.05 and 7.10 a.m. at Furusato 2.0 km distant from the source of disturbance, the white vapours projected up streaming down in the fashion of ash-smokes. Again, on April 27th, the sounds from the same source were heard at Furusato with a moderate loudness for five min. from 2.19 to 2.24 p.m., continued more or less distinctly for further 4 min.; also moderately loud for about three min. between 4.42.30 and 4.45.20 p.m., continuing faint for three min. more. In these cases the frequency of the puffing noises was about 3 in one second. The Shiwofuki-zaki was also active on the afternoon of the 28th of April (1915): the rushing sounds, which accompanied the steam emission, commenced from 5.09.00 p.m., were loud for $6\frac{1}{3}$ min. till 5.15.20 p.m., remained faint till 5.19.40 p.m., then continued with an increased intensity till after 5.30.00 p.m., and ceased to be audible at 6.05.00 p.m.; the vapours, however, continuing to rise more or less for many minutes more.

The Arimra-zaki, of the greatest elongation, was naturally the main or most energetic branch of the lava outflows, and at the end

of April 1915 must have been still continuing its progressive movement, though with a small rate (§ 56). When approached in a boat during the day time, on the 25th of the same month, the apex of the cape was found cracked and the inside red hot molten mass was exposed to view, while the steaming crustal lava blocks constantly crumbled down, hissing into the water. During the clear nights of the 21st and 26th, April, some faint red spots at the same place were visible from Furusato.

While sailing on the morning of April 25th, 1915, in a small boat along the new Arimra lava coast, I had the fortune to witness from a short distance one of the powerful steam and water ejections from the apex of Shiwofuki-zaki which was really the display of a geyser in a small scale. (See fig. 128.) The ejection, accompanied with loud rumbling sounds, began at 9.37 a.m. and lasted $10\frac{1}{2}$ minutes, during which interval the white steam was sent up to the height of 40 or 50 m, while a water spray was thrown from an orifice at sea-level and about $\frac{1}{2}$ metre in

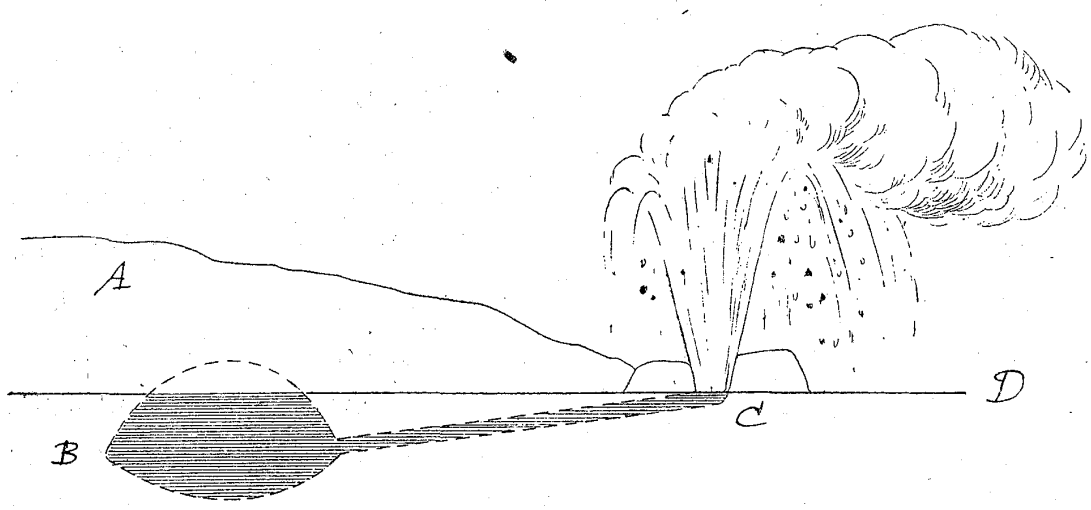


Fig. 129. Diagram illustrating the geyser phenomena at the end of the new lava Shiwofuki-zaki.

D.....Sea surface. A.....Lava stream.
B.....Interior chamber. C.....The orifice.

diameter, through the vertical distance of about 5 metres so vigorously that small lava fragments were often projected up to a height of a few metres. The process of the geyser formation may be illustrated diagrammatically as in fig. 129; the orifice C being supposed to be in communication with a highly heated interior chamber B, whose upper portion is above the sea-level. When the vapour tension generated in the chamber B was sufficiently increased and reached an amount more than counterbalanced by the water pressure in the column BC, there would result a steam and water spouting from the orifice C. Now the velocity with which the water was projected from the latter was approximately $\sqrt{2\times 10\times 5}=$ 10 m/sec. Hence the total amount of the water ejected during the eruption above described would be about $\pi\times\frac{1}{16}\times 10\times 630 = 1220$ c.m. or $\overline{10.7\text{m}^3}$. The volume of the chamber B here supposed would thus roughly be equivalent to that of a 10-metre cube.

56. Forward progress of lava. The 2nd stage lava outflow seems to have been completed in a comparatively short time interval. Thus, between the 23rd and 28th of April, 1915, there was no special progress of the new lava protuberances, although the furthest end of the latter still indicated red-hot portions. Measuring from a given point on the head of Tatsu-zaki (lava flow of 1779 situated to the W. of Yunohama), the angle between the S. base of Eno-shima and the end of the new Shiwofuki-zaki, which exhibited the geyser phenomena, was increased from 0° 15′ to 0° 45′ in the course of 5 months between April 23rd and Sept. 22nd, in 1915. As the distance of the point in question from the place of observation was 1600 m, this angular difference corresponds to a total forward progress of about 14 m of the apex of the lava cape, or to an average rate of approximately 0.1 m per day in the time interval concerned.