composed of a series of broad concentric arcs or portions of spherical surfaces, as is beautifully exhibited at portions of the ridges of the new Arimra-jima. The forms of this type were also found in a more or less clear manner at the N.W. corner of the western lava field, which projects from the S. base of Hakamagoshi into the Kagoshima channel; being the results, in this case, of the quiet oozing out of the molten lava mass, under a great horizontal pressure, from the end or side of the earlier lava streams.

Chapter VI. Volume Densities of Sakura-jima Lavas.

42. Volume density of lava.* Suppose a more or less porous piece of lava, of weight=W, to be immersed in water and to absorve moisture to the amount of W′−W. If W″ denote its weight

* The results of some of the chemical analysis of the recent Sakura-jima ejecta carried on at the Imperial Geological Survey and the Fukuoka Mining Bureau are as follows:—

Composition.	(1). Ashes collected in Kagoshima.	(2). Lava.	(3). A dark lava piece found at the vicinity of Krokami.
SiO_2	63.39	60.59	58.72
Al_2O_3	16.75	17.77	21.83
Fe_2O_3	3.10	1.23	3.02
FeO	4.00	5.59	6.37
CaO	5.38	6.34	6.68
MgO	1.43	2.39	0.20
Na_2O	3.50	3.04	1.21
K_2O	1.32	1.68	0.47
Moisture (free).	0.62	0.59	0.31
P_2O	—	0.08	
MnO	0.03	0.24	
TiO_2	0.57	0.71	
SO_3	—	0.23	
P_2O_5	0.20		
Soluble silica.	15.73		

(1) and (2) are quoted from Prof. D. Sato's report on the eruption of Sakura-jima given in the Bulletin of the Imp. Geol. Survey, 1914, and (3) from Dr. N. Ishikawa's account of the same volcanic disturbance given in the Sakura-jima Number of the Tokyo Geographical Society publications, 1915.

Sakura jima Eruption of 1914 : New Islets at the E. extremity of the Seto Strait Lava.
(April, 1915. F. Omori, photo.)

Fig. 114. "Inner" side of one of the small islets of the Ushine-jima group.

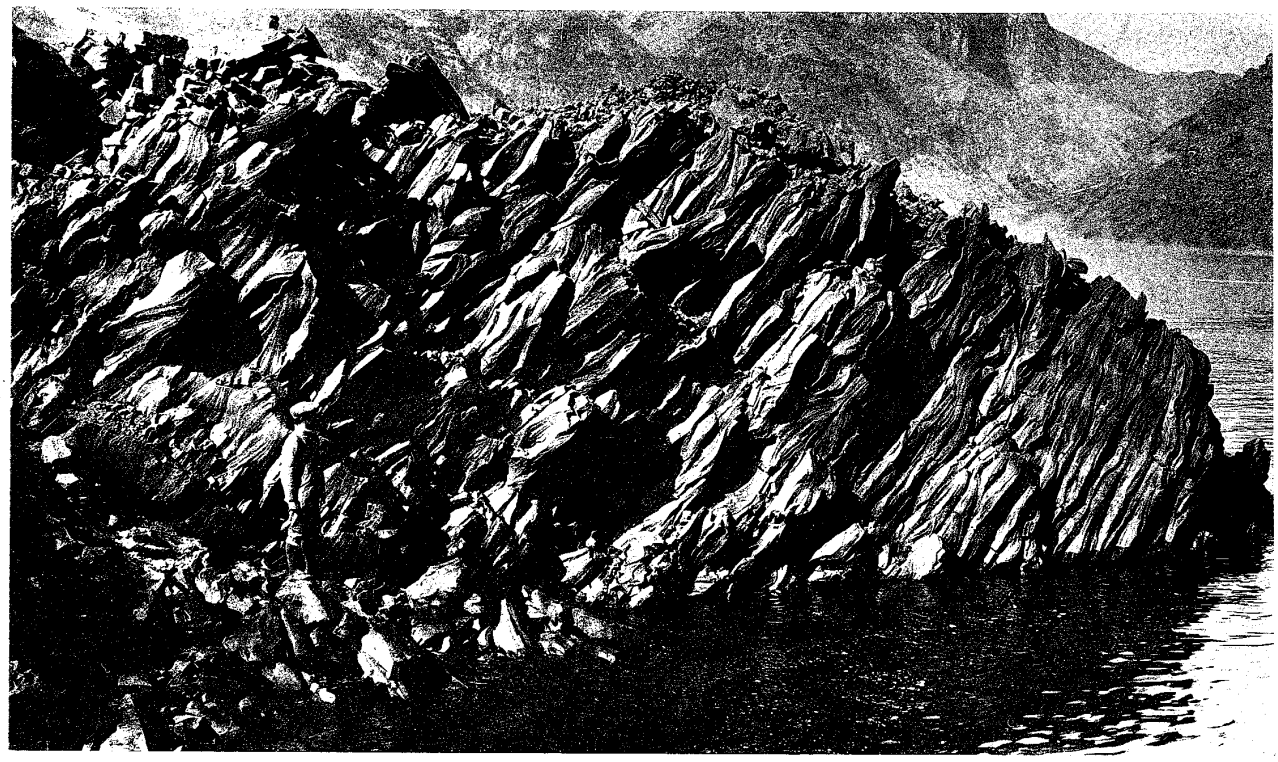

Fig. 115. "Inner" vertical side of Oshima, or the principal islet, of the Ushine-jime group.

Sakura-jima Eruption of 1914 : New Islets at the E. extremity of the Seto Strait Lava.
(April, 1915. F. Omori, photo.)

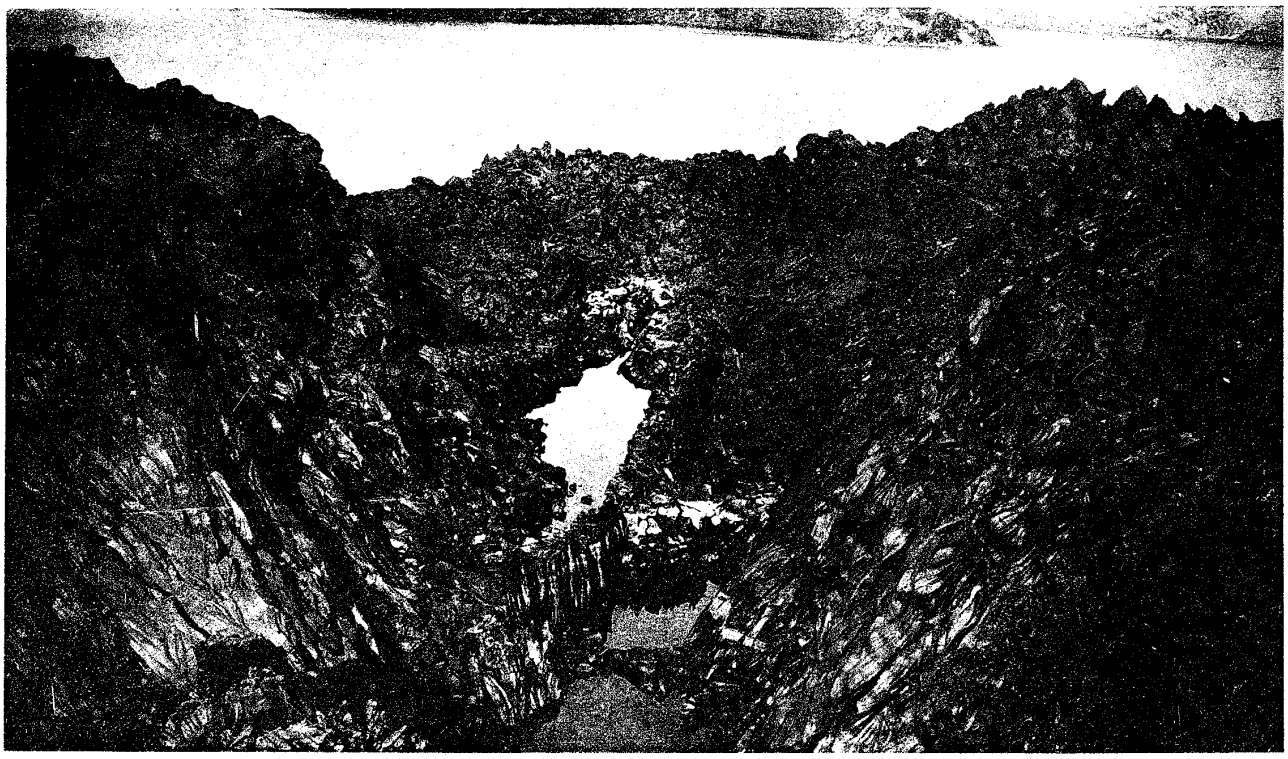

Fig. 116. The central longitudinal Cleavage Canal of Nagasaki-jima islet, showing the vertical fence-like partition wall at the middle.

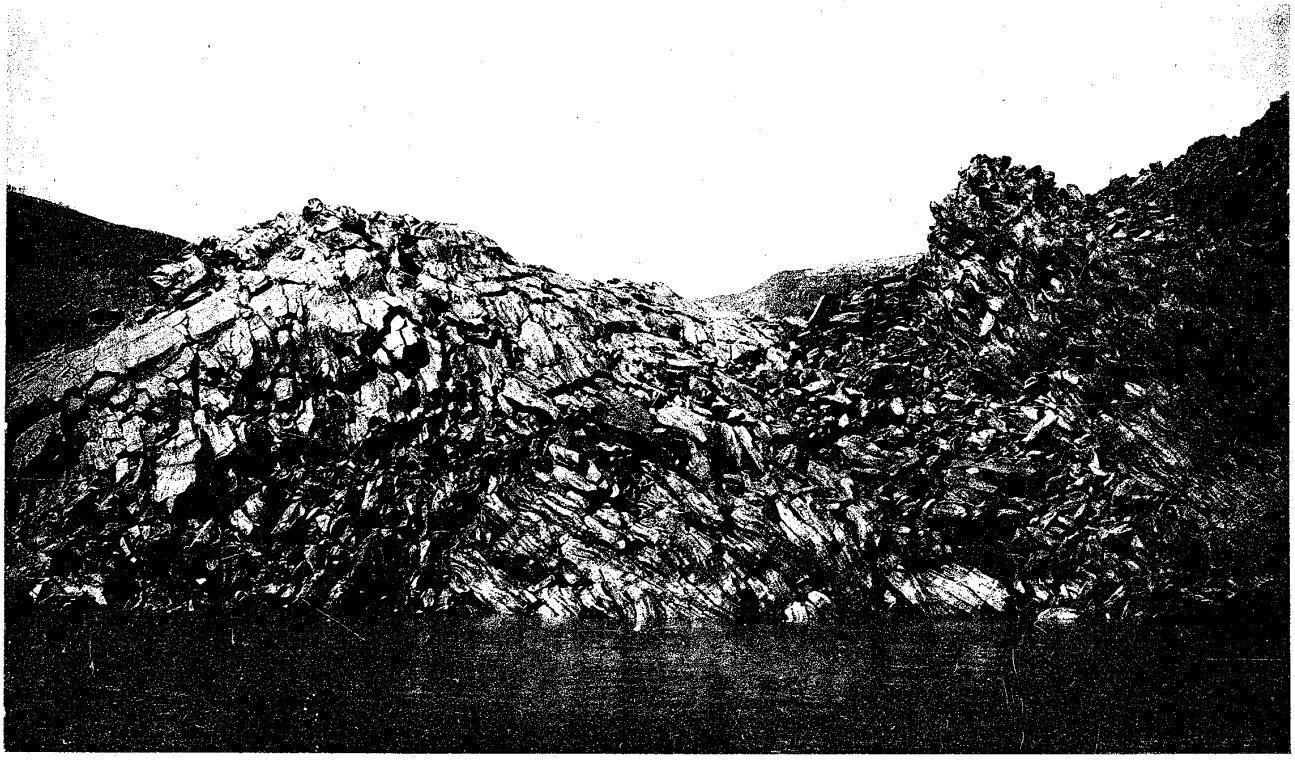

Fig. 117. Outer side of a lava islet, whose W. half has been buried under the Seto Strait lava outflow.

in water after a sufficiently long immersion, then the *approximate* volume density of lava may be calculated as follows:—

$$\text{Volume Density} = \frac{W}{W' - W''}$$

In Table VI, at the end of this chapter, are given the volume densities calculated according to the above process of 89 specimens of lava collected at the recent eastern and western eruption fields of Sakura-jima. The water absorption was almost *nil* for some of the hard compact lava pieces, but amounted to 50% or more for some of the pumiceous specimens.

It is noteworthy that, for the new lava islets of Arimra-jima, Nagasaki-jima, and Ushine-Oshima, the density is practically constant, being mostly included between 2.62 and 2.59, with the mean value of 2.60. This uniformity of the density is what may be expected from the nature of the islets in question which have been formed by the squeezing out of the molten rock from the cracks in the upper crust of the submarine lava flows. The volume density of the mass of magma existing under the volcano may possibly be identical with the mean value of 2.6 here obtained.

For the eastern eruption field, the density of the rock specimens taken from the lava flows varied between 2.84 and 1.49 with the mean of 2.26; that of the new lava pieces projected from the different craterlets on the same side varying between 2.67 and 1.54, with the practically identical mean of 2.23. For the western eruption field, the rock specimens taken from the lava flows had the density of 2.57 to 1.06, with the mean of 2.12. These values may probably be taken as approximately representing the average densities of the lava composing the main portion of the lava streams: say, 2.3 and 2.1 respectively for the eastern and the

western eruption fields. By way of comparison, it may be noted (Table VI') that a few specimens of the old lavas forming the higher side wall of the eastern No. 1 craterlet and the top wall of Minami-dake, as well as those of the Anei (1779) and the Bummei (1475) eruptions indicated nearly the same results, the density being 2.53 to 2.16, with the mean value of 2.4.

The bombs, mostly of bread-crust appearance, had generally a low density: the mean value for the specimens collected on the eastern and the western fields being respectively 2.0 and 1.3.

The ordinary pumice pieces collected on the western eruption field had the densities of 0.90 to 0.57, with the mean of 0.75.*

On the whole, the rocks on the western eruption field, at least so far as the projected pieces and the superficial portion of the lava streams are concerned, seem to have in several instances densities slightly less than those on the eastern field. This may possibly indicate that the explosive action at the initial stage of the eruption was more violent on the western than on the eastern scene of disturbance: a supposition which apparently finds support in the facts that the first explosive outburst on the W. side took place earlier and at a higher level than that on the E. side. It seems also possible that the lava on the latter side had a somewhat deeper origin or reservoir than that on the former.

Lava of Swanose-jima and Nakano-shima. For the sake of comparison, I give in Table VI' the values of the density of the rocks of Swanose-jima and Nakano-shima, two of the most conspicuous among the Satsuma volcanic islands. The specimens from the crater walls or old lava flows had a mean value of about 2.6, being equal to that of the rock in the new Sakura-jima lava

* A fine specimen of very light glassy pumice was found below the lava source No. 3, near the Yokomine hill on the western field.

islets. The density of the bombs was somewhat smaller, being in the mean 2.3 both for Swanose-jima and for Nakano-shima.

43. Ashes. The volume density of the Sakura-jima ashes, generally fine and ashy in colour, determined from a few samples brought to Tokyo, was as follows :—

Date of Ash-precipitation.	Place where Sample was collected.	Volume Density of Ashes in natural condition.
Jan. 17, 1914.	S. part of the city of Kagoshima.	0.86
„ 19, „	On board the steamer *Nishiki-maru*, in Kagoshima Harbour.	1.00
„ 12–22, „	N.W. base of Nabe-yama.	0.95
„ „ , „	Village of Furusato.	1.20

The following results relating to the volume density of the samples of ashes collected at different places in Sakura-jima in Jan. and Feb., 1914, are reproduced from the report of the Kagoshima Forestry Office on the effects of the eruption on forestry :—

Locality.	Weight per cubic *sun*(1)	Volume Density.	Remarks.
	momme. (2)		
At Krokami.	8.3	1.0	Mixed with sand particles of the size of rice grains.
Vicinity of Krokami.	8.4	1.0	„
On Nabe-yama.	10.0	1.2	„
Gongen-yama, (near Nabe-yama.)	9.3	1.1	„
Wariishi-zaki.	9.3	1.1	Mixing no sand particles.
Vicinity of Yunohama.	7.6	0.9	With a comparatively strong acidity, and mixing pumice fragments of the size of poppy seed.
Above Yunohama.	7.4	0.9	Mixing black sands of the size of poppy seeds.
Tobashira-hana (Sakkabira).	7.4	0.9	„
Vicinity of Arimra.	5.9	0.7	Mixing pumice particles of the size of poppy seeds.
Coast of Ushine.	8.9	1.1	Mixing pumice particles of the size of rice grains.

(1) 1 *sun* = 3.03 cm = 0.1 foot very nearly. (2) 1 *momme* = 3.75 grams.

According to the investigations made at the Kagoshima Agricultural Experiments Station, the real density of the ashes precipitated in Kagoshima on Jan. 19th, 1914, had the mean value of 2.63, which is practically identical with the volume density of the compact lavas forming the new islets considered in § 42. The volume density of, and the amount of the moisture contained in, the ashes were as follows :—

Date of Ash-precipitation. (Jan. 1914.)	Locality of sample collection.	Ashes.	Amount of Moisture contained in Ashes.	Volume Density of Ashes (freed of moisture).
19th.	Kagoshima City.	Fine and ashy white.	—	0.81 (coarse). 1.02 (fine).
15th.	Nishi-Kokbu.	Ashy white, mixed with some coarse particles.	10.77	0.86
14th.	Iwakawa.	Mixed with dark pumice particles.	12.71	0.89
29th.	Eastern part of Sakura-jima.	Fine and ashy white.	6.34	0.95

Comparing together the different results above noted, the volume density of the Sakura-jima ashes in the original moisture-containing condition is included between 0.7 and 1.2, with the mean value of 1.00. The new ash-layer is thus of the same weight as water, being some 10 to 12 times heavier than newly fallen snow. The volume density of the ashes deprived of its moisture is between 0.81 and 1.02, with the mean value of 0.91.

According to the examinations made at the Kagoshima Agricultural Experiments Station, the percentage amounts at different places within the Kagoshima prefecture of the solid particles in the Sakura-jima ashes of diameter under 0.5 mm, over 1.0 mm, and over 4.0 mm were as follows :—

TABLE. V. Total Percentage Amount of Ash-particles of different Diameters.

地名（村，字）	Locality.	Diameter < 0.5 mm.
上荒田（鹿兒島市外）	Kami-Arada (Kagoshima).	99.8
赤生原（櫻島西端）	Akobaru (Sakura-jima).	96.0
白濱（ ,, 北部）	Shirahama ,,	97.5
湯之（ ,, 南西部）	Yuno ,,	98.4
古里（ ,, 南部）	Furusato ,,	91.5
西襲山西光寺	Nishi-Soyama. (Aira county, Ōsumi).	92.0
國分上小川	Kokbu. ,,	96.9
山田，下名（姶良郡）	Yamada ,,	97.0
蒲生，上久德（ ,, ）	Gamo ,,	98.5
溝邊，有川（ ,, ）	Mizobe ,,	99.0
横川，中野（ ,, ）	Yokogawa ,,	99.5
栗野，木場（ ,, ）	Krino ,,	99.5
吉松，川西（ ,, ）	Yoshimatsu ,,	100.0
財部，南俣（噌唹郡）	Takarabe (Sō county, Ōsumi).	96.5
鹿屋，秡川（肝屬郡）	Kanoya (Kimotsuki county, Ōsumi).	99.9
高隈，下高隈	Takakma ,,	97.5
垂水，田神	Tarumizu ,,	97.0
高隈，麓	Takakma Fumoto ,,	96.0
花岡，木谷	Hanaoka ,,	100.0
新城，新城	Shinjo ,,	100.0
垂水，柊原	Tarumizu, Hiiragibaru ,,	97.0

地名（村，字）	Locality.	Diameter > 1.0 mm	Diameter > 4.0 mm
藤野（櫻島西北部）	Fujino (Sakura-jima).	69.5	3.50
西道（ ,, ）	Saido ,,	30.0	—
福山，牧ノ原	Fukuyama.	12.5	—
西國分	Nishi Kokbu.	20.0	—
西志布志，伊崎田	Nishi-Shibshi.	15.6	1.7

TABLE V. (*Continued.*)

地名（村，字）	Locality.	Diameter > 1.0 mm	Diameter > 4.0 mm
東國分，小村	Higashi Kokbu.	11.0	—
恒吉，長次	Tsuneyoshi.	10.0	—
牛根，二川	Ushine.	27.0	12.0
,,	,,	38.8	6.0
,,	,,	63.0	14.0
垂水，脇登	Tarumizu.	29.5	1.0

Referring to the map indicating the amount of the precipitation of the ashes in the southern part of Kyushu (fig. 33, in the preceding Number of the Bulletin), we see that the districts, where the constituents of the Sakura-jima ejecta of diameter over 1.0 mm was greater than 10%, approximately coincides with the area enclosed by the curve of 3 *sun* (= 9 cm) ash-accumulation. Again the zone, in which the amount of the particles of the size greater than 4 mm was over 6%, practically coincides with that enclosed by the curve of 30 *sun* (= 0.9 metre) ash-accumulation. At the E. and N. extremities of the 5 *sun* (= 15 cm) accumulation area, the particles of diameter greater than 4 mm were respectively 0.5 and 1.7% in amount.

TABLE VI. Volume Density of the new Sakura-jima Lavas.

Date of sample collection.	Locality.	Volume Density.
	(I) New Lava Islets.	
April 25, 1915.	Arimra-jima.	2.62
		2.61
		2.60
		2.59
		2.61

TABLE VI. *(Continued.)*

Date of sample collection.	Locality.	Volume Density.
May 5, 1915.	Ushine-Oshima.	2.60
		2.59
		2.36
,, ,,	Nagasaki-jima.	2.60
		2.07
	(II) Eastern Lava Flows.	
Jan. 24, 1914.	At Yubama (Yunohama) beach.	2.12
,, ,,		1.95
Sept. 27, ,,		2.03
,, ,,		2.54
,, ,,		2.51
,, ,,		2.62
April 21, 1915.		2.60
,, ,,		2.60
,, ,,		2.61
,, ,,		1.93
,, 25, ,,		2.16
April 12, 1914.	Seto " Strait " Lava.	2.37
Sept. 29, ,,		2.07
,, ,,		1.66
April 25, 1915.		2.51
Sept. 29, 1914.	Below No. 1 Craterlet.	1.84
Jan. 23, 1914.	Vicinity of Krokami.	1.92
,, ,,		1.49
Oct. 2, ,,		2.84
,, ,,		2.55

TABLE VI. (*Continued.*

Date of sample collection.	Locality.	Volume Density.
Oct. 2, 1914.	Vicinity of Krokami.	2.46
,, ,,		2.28
(III) Lava Pieces newly projected from the Eastern Craterlets.		
April 9, 1914.	Vicinity of No. 1 Craterlet.	2.57
,, ,,		2.25
,, ,,		2.18
,, ,,		2.27
,, ,,		2.40
,, ,,		1.91
Sept. 27, ,,		2.46
,, ,,		2.28
,, ,,		2.18
,, ,,		1.67
April 22, 1915.	Vicinity of No. 2 Craterlet.	2.08
,, 23, ,,	,, No. 3 ,,	2.19
,, ,, ,,	,, No. 4′ ,,	2.67
Jan. 23, 1914.	Nabe-yama: N. base.	2.16
April 9, ,,	,, : N.W. top.	2.24
May 4, 1915.	,, : S.E. slope.	2.65
,, ,,	,, ,,	2.42
,, ,,	,, ,,	1.62
,, ,,	,, : N. base.	1.54
Sept. 22, ,,	,, : S.E. top.	2.55
,, ,,	,, ,,	2.44
(IV) Western Lava Flows.		
Jan. 18, 1914.	Vicinity of Yokoyama.	1.06
,, 22, ,,	Near Hakamagoshi.	1.63

TABLE VI. (*Continued.*)

Date of sample collection.	Locality.	Volume Density.
Jan. 22, 1914.	Above Akobaru. (Specimen taken from a large lava block.)	2.19
April 8, 1915.	,,	2.51
,, ,,	,,	2.48
May 6, ,,	Tora-zaki, or N.W. corner of the lava field.	2.45
,, ,,	,,	2.27
Sept. 30, 1915.	Vicinity of the former Karasu-jima.	2.57
		2.48
		2.47
		2.48
		2.39
		2.32
		2.34
		2.32
		2.29
		2.26
		2.24
		2.09
		1.70
		1.48
		1.49
		1.32
(V) Lava Pieces projected from the Western Craterlets.		
April 8, 1915.	At Bottom of No. 1 Craterlet.	2.16
		2.02
(VI) Bombs from the Eastern Craterlets.		
Jan. 24, 1914.	At the N.W. foot of Nabe-yama.	2.81
April 23, 1915.	Between Craterlets Nos. 3 and 4.	1.94

TABLE VI. (*Continued.*)

Date of sample collection.	Locality.	Volume Density.
April 23, 1915.	Between Craterlets Nos. 2 and 3.	1.71
„ 25, „	„ „ „	1.58
	(**VII**) Bombs from the Western Craterlets.	
April 9, 1914.	Near Akobaru.	1.34
		1.29
		1.19
	(**VIII**) Pumice.	
Jan. 18, 1914.	Near Koike.	0.90
		0.85
		0.66
		0.57

TABLE VI'. Volume Densities of old Sakura-jima Lavas.

Locality.	Volume Density.
W. side wall of Eastern No. 1 Craterlet.	2.53
	2.45
Anei (1779) Lava, at Furusato.	2.47
	2.34
Bummei (1475) Lava, forming the wall of an old craterlet, near Yuno.	2.49
Minami-dake Top.	2.16
	2.16

TABLE VII. Volume Density of Lavas and Bombs of Swanose-jima and Nakano-shima.

Lava.		Volume Density of Bombs.
Locality.	Volume Density.	
Swanose-jima.		
Lava pieces recently projected, found at the vicinity of Trigonometrical Point.	2.76	2.57
	2.76	2.44
	2.69	2.43
	2.54	2.32
1813 (文化十年) lava flow, at Akazome-ura (赤染浦).	2.58	2.37
	2.27	1.75
Lava forming the wall of 1813 (文化十年) craterlet.	2.67	2.31 (mean.)
	2.56	
	2.60 (mean.)	
Nakano-shima.		
Lava forming the wall of the old crater.	2.60	2.67
	2.56	2.60
	2.58 (mean.)	2.46
		2.32
		2.10
		1.67
		2.30 (mean.)

Chapter VII. Heating Effect of the Submerged Lava Flows on the Sea Water.

44. Surface sea-water temperature before the eruption. The Kagoshima meteorological observatory carried on, from 1910 to 1912, the observation of the surface sea-water temperature at the quay of the Kagoshima harbour, the measurement having been made