

## Geological and Petrological Studies of the “Shirasu” in South Kyushu, Japan Part III. : The “Shirasu” in the Tsuruda-Hiwaki-Koriyama Area, North of Kagoshima City

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## Geological and Petrological Studies of the "Shirasu" in South Kyushu, Japan

### Part III. The "Shirasu" in the Tsuruda-Hiwaki- Koriyama Area, North of Kagoshima City<sup>1)</sup>\*

By

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#### Geological Occurrence

##### 1. *Outline of geology* (Figs. 1, 2)

Geologic units of the area under consideration are Cainozoic volcanic rocks, perhaps Pliocene—Plio-Pleistocene sediments, and basement rocks which consists largely of Mesozoic sediments and post-Mesozoic (perhaps Miocene) granitic rocks.

The general stratigraphic succession and the succession of the volcanic rocks in this area are generalised as respectively shown in Tables 1 and 2. Most of the data for this generalization have been obtained from actual contact relations between the rocks, though some of them are of inference.

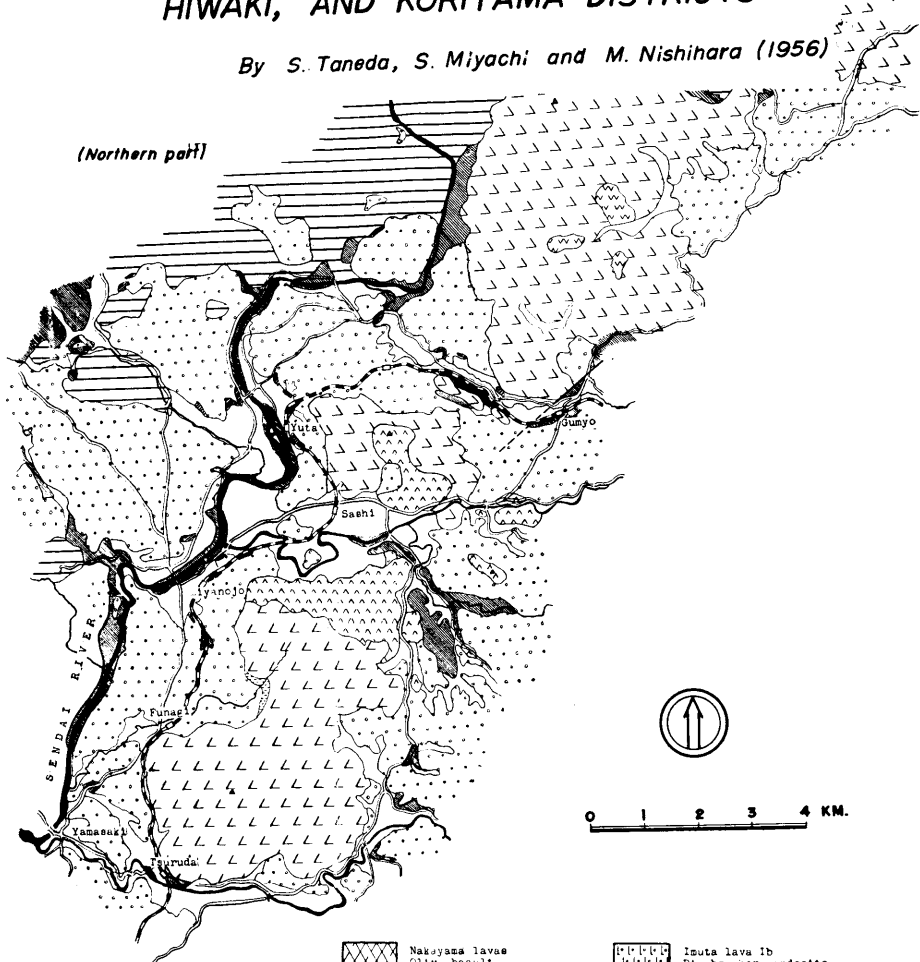
The volcanic rocks in and around this area vary in composition from basaltic to rhyodacitic or rhyolitic, occurring as lava flow, tuff-breccia, welded tuff, tuff, a kind of pumice flow and pumice loam, sometimes interbedded with some sediments. Of these, the welded tuff is commonly called in Kyushu the "Hai-ishi," that means "ash stone." The succeeding "Shirasu" in this area has as usual a general appearance of either loose lapilli tuff, or loose tuff breccia, or loose volcanic breccia (Fig. 3, b, c) characterized by abundant glassy or pumiceous fragments. This rock as described below is comparable in its lithological character to that of a kind of pumice flow. The Holocene pumice loam bed, which is always composed of three or more layers, covers all the rocks mentioned above.

1) In this paper are given the geological and petrological descriptions of the "Shirasu" in the northern part of the "Shirasu" area, South Kyushu.

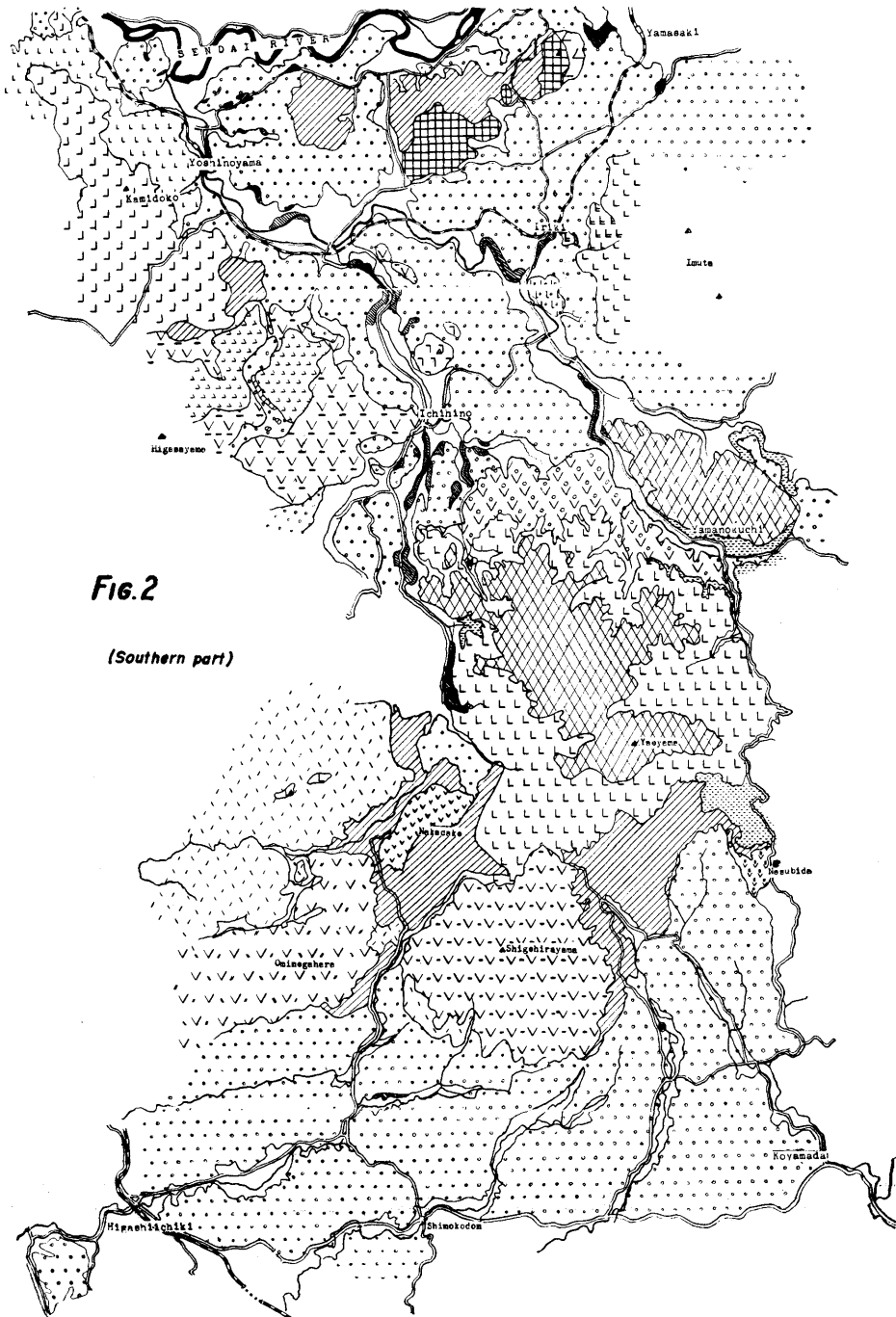
\* Received December 10, 1956.

# Fig.1 GEOLOGIC MAP OF THE TSURUDA, HIWAKI, AND KORIYAMA DISTRICTS

By S. Taneda, S. Miyachi and M. Nishihara (1956)

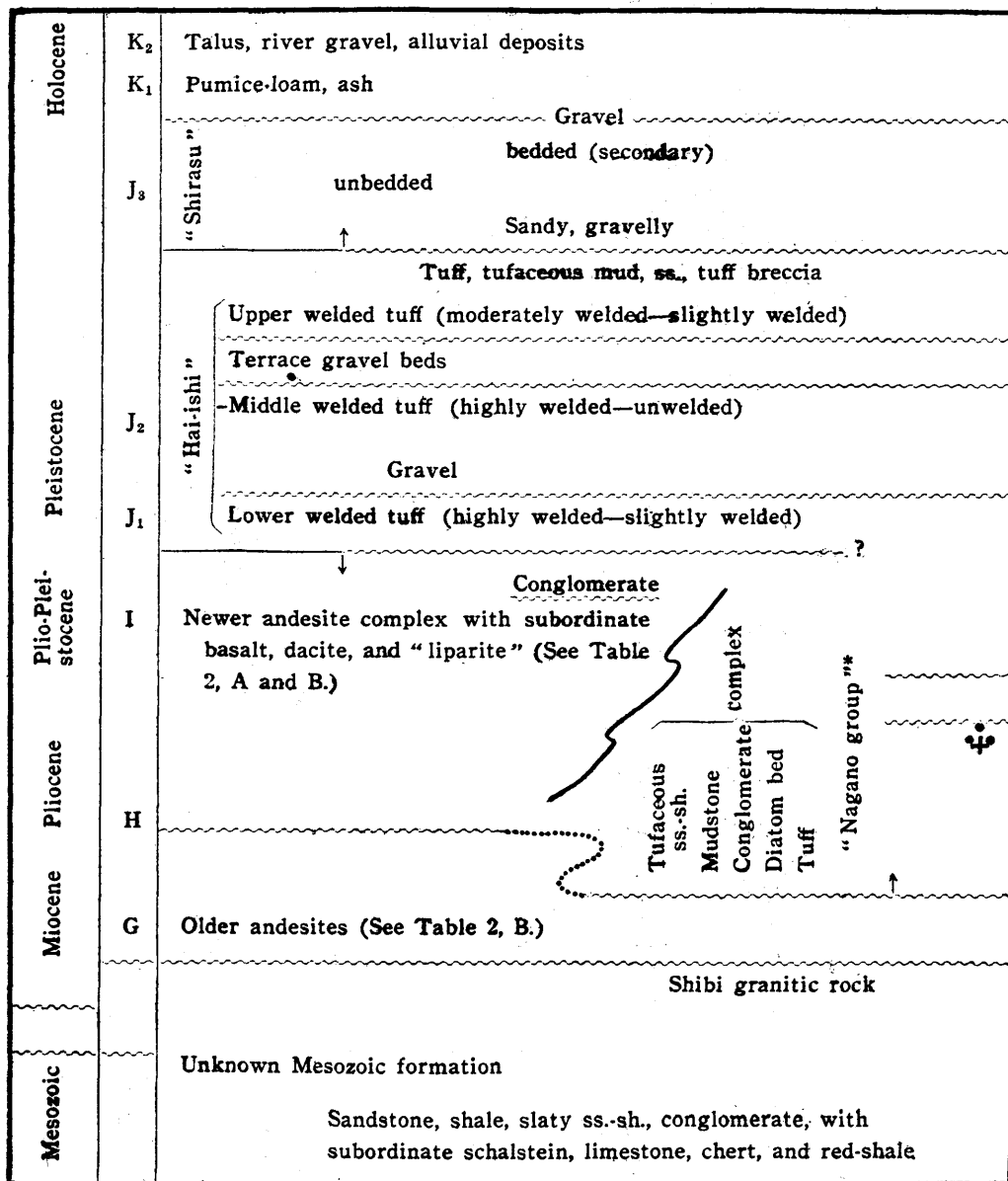


	Alluvium		Nakayama lavae Oliv. basalt		Inuta lava Ib Bl.-bg. nor. andesite
	"Shirasu"		Sedimentaries (Nagano group)		Yaeyama lava II Aug.-hyp. andesite
	Upper "Hakishi"		Omura lava Aug.-hyp. andesite		Gungyo lava I Aug.-hyp. andesite
	Middle "Hakishi"		Higasayama lava I Aug.-hyp. andesite		Inuta lava Ia Hor. andesite
	Lower "Hakishi"		Kamidoko lava I Hor.-bg. two-pyr. andesite		Yaeyama lava I Two-pyr. andesite
	Hiwaki lava Oliv.-bg. two-pyr. andesite		Inuta lava II Hor.-bg. two-pyr. andesite		Shisenriyama lava Two-pyr. andesite
	Higasayama lava II Aug.-hyp. andesite		Yaeyama lava III Two-pyr.-hor. andesite		Omizahara lava Two-pyr. andesite
	Kamidoko lava II Hor.-hyp. andesite		Okoba lava Two-pyr. rhyolitic andesite		Nakadaze lava Two-pyr. andesite
	Yaeyama lava IV Oliv. basalt		Sashi lava Aug.-hyp. andesite		Nasutida lava Two-pyr. andesite(propylite)
			Gungyo lava II Aug.-hyp. andesite		Unknown Mesozoic formation



**Fig. 2**  
*(Southern part)*

Table 1. General Stratigraphic Succession



\* We propose a group name "Nagano" for the sediments which have been known as "Nagano formation," "Imuta formation," and "Yamanokuchi formation," in the Nagano, Tsuruda, Hiwaki and Koriyama areas.

Table 2. Succession of the Volcanic Rocks of Upper Miocene-Pleistocene Age

(A)

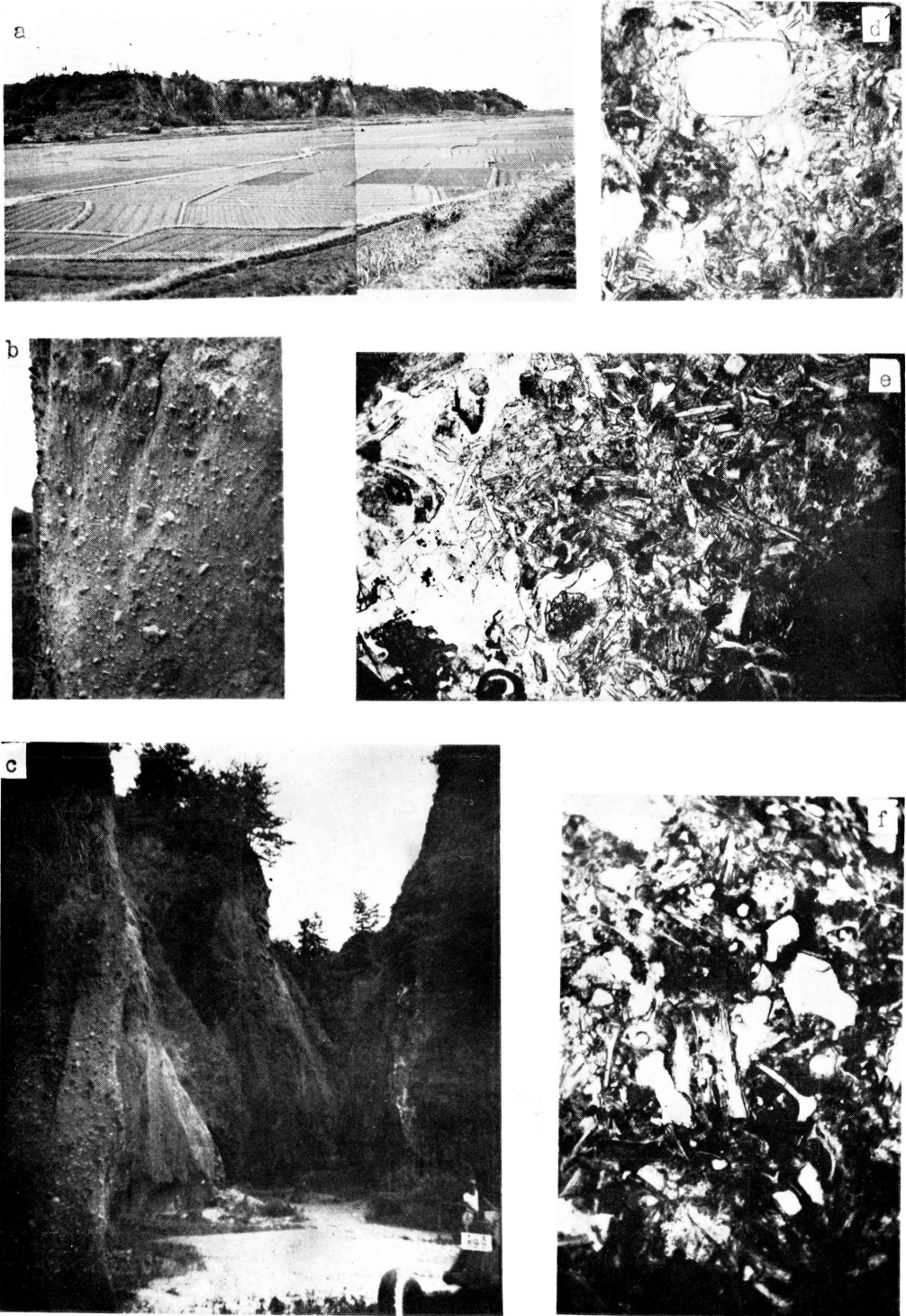
Geol. time (provisional)		Gumyo field	Higasayama field	
Pleistocene	J	"Hai-ishi," "Shirasu"	"Hai-ishi" "Shirasu"	"Hai-ishi," "Shirasu"
	?			
Pliocene	I	Hiwaki lava: Ol-bearing two-px andesite (basic) Omura lava: Au-hy andesite	Higasayama lava II: Au-hy basaltic andesite Higasayama lava I: Au-hy andesite	Kamidoko lava II: Ho-bearing hy andesite (basic) Kamidoko lava I: Ho-bearing hy andesite
	H	Sashi lava: Two-px andesite Gumyo lava II: Two-px andesite		
Pliocene	?	Gumyo lava I: Two-px andesite		

Table 2.

(B)

Geol. time (provisional)		Imuta field	Yaeyama field	Nakayama field
Pleistocene	J	"Hai-ishi," "Shirasu"	"Hai-ishi," "Shirasu"	"Hai-ishi," "Shirasu"
	I		Yaeyama lava IV: Ol basalt	Nakayama lavas: Ol basalt
Pliocene	H	Imuta lava II: Ho-bearing two-px andesite Tufaceous ss. Imuta lava Ib: Bi-bearing ho andesite	Yaeyama lava III: Two-px-ho andesite Sedimentaries Yaeyama lava II: Two-px andesite	"Tuffite, tuf. ss. Cg. Muddy ss. Cg. Alternation of tuf., ss., and sh.
	G?	Imuta lava Ia: Ho andesite Sediments Propylite	Yaeyama lava I: Two-px andesite Sediments Nasubida lava: Two-px andesite	Sediments: "Yamanokuchi formation"

Fig. 3. (See the explanation of the next page.)



## 2. The "Hai-ishi" and "Shirasu"

The "Hai-ishi" is divided in order of eruption into three: the upper, the middle, and the lower "Hai-ishi" or welded tuff. The upper and the middle "Hai-ishi" are extensively distributed and conceivable to have been issued by enormous explosions at a distance. The lower "Hai-ishi" is found locally in several very narrow areas, and seems to have been poured out from widely separated vents or fissures.

Along the Sendai River to the north of Kagoshima Bay the "Shirasu" about 50 to 90 m thick forms a table land, 250 m or less in altitude. It is noted that there is no regularity that its thickness increases towards a certain area.

The bottom of the "Shirasu" bed, usually less than 1 m thick, is sandy, clayey, or gravelly. In a few places the bottoms as thick as 1-2 m are decomposed by weathering to clay. Between the "Shirasu" and the underlying rocks, such as "Hai-ishi," tuffaceous shale and sandstone, and andesite, are met with thin limonite layers, which, usually 1-10 cm thick, are in places undulated and swollen up to 20 cm or slightly more.

The uppermost part (usually less than several meters from the surface) are somewhat bedded at some places, so that it has been considered a secondary deposit derived from the primary "Shirasu." A clayey matter, the weathering product from the "Shirasu," is frequently met with near the surface.

Carbonized plants are found from several places in the Omura and Ichihino fields. They are soot and natural charcoal in the form of trunk with varying size, reaching 20 cm in diameter and 2-3 m in length.

### Structure and Texture

Usually the "Shirasu" shows no bedding, but a chaotic structure owing to a noteworthy proportion of fragments of varying size. As the general description of the features of the "Shirasu" proper was given in TANEDA's previous paper (1957), only a few additional notes will be given below.

Sometimes in the "Shirasu" bed are scattered nearly vertical "lapilli pipes," ranging in size from several centimeters to 1 m in length and from 1 to 20 cm in diameter; they are often bent and branched, and filled up with comparatively large fragments and small crystals usually 1 mm in diameter (Fig. 4). Moreover, lenticular masses or bands consisting largely of accessory fragments of compact

Fig. 3.

- a. Plateau-like table land composed of the "Shirasu." Eguchiura, Higashi-ichiki town.
- b. Natural surface of the "Shirasu" bed at the right end of the table land in the above photograph.
- c. Cliffs in the "Shirasu" bed.
- d. Photomicrograph of the "Shirasu" from Koyamada, Kagoshima city. Nearly horizontal section.  $\times 42$ .
- e. Photomicrograph of the "Shirasu" from Kushikino city. Vertical section.  $\times 48$ .
- f. Photomicrograph of the "Shirasu" from Koyamada, Kagoshima city. Vertical section.  $\times 48$ .



andesites are noted to occur infrequently intercalated within the deposits. In addition, though of rare occurrence, pumice of a bedded structure, up to few meters thick, predominates usually in the basal part of the "Shirasu" bed.

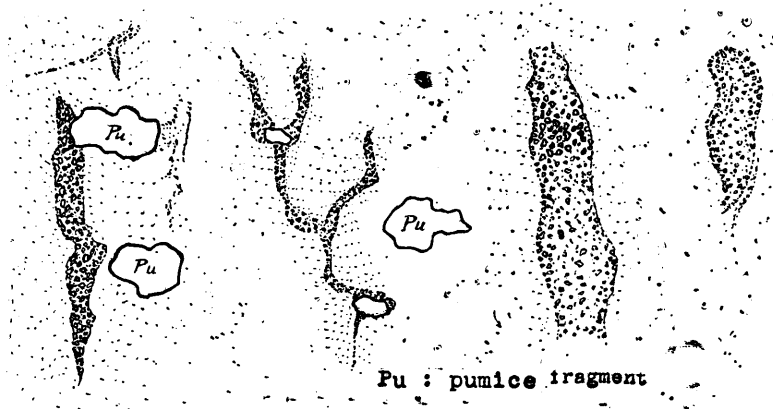


Fig. 4. "Lapillic pipes" in the "Shirasu."

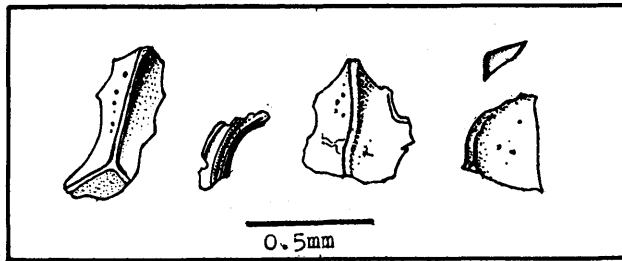


Fig. 5. Shape of glass particles of the "Shirasu."

The microtexture of the "Shirasu" bed was observed to prove that it is vitroclastic and shows no difference in different directions (Fig. 3, d, e, f).<sup>2)</sup>

#### Size Distribution

1. *Mechanical analysis.* One hundred samples of the "Shirasu" excluding the large rock fragments exceeding 4 mm in diameter and nine samples of the whole "Shirasu" (including rock fragments larger than 4 mm) were mechanically analysed. The results are given in Table 3 and 4 and shown in Figs. 6, 7, 8, and 9. At a glance it may be seen that the "Shirasu" bed in the area in question shows close resemblance in bad sorting to the "Older pumice" of the Crater Lake Region (MOORE, 1934; TANEDA, 1954, Fig. 7).

2) Thin sections were prepared by the method mentioned elsewhere (TANEDA, 1954 and 1957):

Table 3. Size distribution of the "Shirasu," excluding large fragments exceeding 4 mm in diameter  
(A)

No.	Size							Md
	4-2	2-1	1-1/2	1/2-1/4	1/4-1/8	1/8-1/16	1/16>	
1	2	5	13	16	22	24	18	0.16
2	2	3	5	22	25	27	16	0.16
3	2	5	9	14	25	23	22	0.14
4	2	6	16	15	22	21	18	0.17
5	3	8	18	15	20	22	14	0.20
6	2	4	11	12	23	23	25	0.13
7	3	10	21	15	19	18	14	0.24
8	1	6	14	16	18	24	21	0.15
9	5	13	16	10	17	19	20	0.19
10	2	5	15	16	22	26	14	0.18
11	3	11	26	14	15	13	18	0.32
12	3	10	17	19	16	19	16	0.25
13	2	7	16	9	17	23	26	0.13
14	1	4	10	19	23	25	18	0.15
15	1	5	18	11	20	31	14	0.14
16	1	5	20	17	23	22	12	0.20
17	2	7	20	14	23	21	13	0.19
18	2	7	27	20	19	18	7	0.32
19	2	7	21	21	20	21	8	0.26
20	4	8	18	10	18	20	22	0.18
21	2	6	16	10	22	24	20	0.14
22	2	6	15	10	23	24	20	0.14
23	3	8	16	12	21	24	16	0.16
24	2	7	17	10	20	24	20	0.15
25	4	7	17	12	20	20	20	0.17
26	3	8	18	16	20	21	14	0.22
27	3	10	19	16	20	22	10	0.23
28	4	10	25	14	17	17	13	0.30
29	7	13	18	15	23	20	4	0.28
30	8	13	14	15	23	18	9	0.25
31	7	9	11	15	25	25	8	0.20
32	7	12	14	16	20	24	7	0.24

Sample localities (T: town, V: village):

- |                                    |                                         |
|------------------------------------|-----------------------------------------|
| 1. South of Miyanojo, Miyanojo T.  | 17. Do.                                 |
| 2. South-east of Hakie, Tsuruda V. | 18. Do.                                 |
| 3. West of Kawaguchi, Tsuruda V.   | 19. Do.                                 |
| 4. Taneda, Tsuruda V.              | 20. East of Suido, Hiwaki T.            |
| 5. North of Tsuruda Station        | 21. Do.                                 |
| 6. Kamisako, Tsuruda V.            | 22. Do.                                 |
| 7. North of Yamasaki V.            | 23. Do.                                 |
| 8. West of Soeda, Iriki T.         | 24. Do.                                 |
| 9. East of Suido, Hiwaki T.        | 25. Do.                                 |
| 10. East of Tonoharu, Hiwaki T.    | 26. Toso, Kagoshima City                |
| 11. South of Ichihino, Hiwaki T.   | 27. Do.                                 |
| 12. North of Fumoto, Iriki T.      | 28. Shiroyama, Kagoshima City           |
| 13. East of Maruyama, Hiwaki T.    | 29. North of Shimokodon, Shimo-ijuin V. |
| 14. North of Iwamoto, Hiwaki T.    | 30. Umeki, Higashi-ichiki T.            |
| 15. Uto, Hiwaki T.                 | 31. Hokonhai, Higashi-ichiki T.         |
| 16. East of Ichihino, Hiwaki T.    | 32. South of Shimokodon, Shimo-ijuin V. |

Nos. 20-25 were taken at a vertical intervals of 5 m on a cliff.

Table 3.  
(B)

No.	Size							Md
	4-2	2-1	1-1/2	1/2-1/4	1/4-1/8	1/8-1/16	1/16>	
33	5	12	16	21	20	17	9	0.28
34	6	10	13	14	25	23	9	0.20
35	4	11	17	19	22	23	4	0.26
36	5	11	13	12	25	26	8	0.19
37	4	9	12	15	25	29	6	0.20
38	5	9	11	13	24	23	15	0.17
39	4	8	9	13	21	29	17	0.14
40	4	7	10	14	21	27	17	0.15
41	5	8	12	13	22	27	13	0.17
42	4	9	15	17	19	26	10	0.21
43	6	9	11	14	21	29	10	0.18
44	4	10	11	16	27	22	10	0.19
45	5	11	19	22	24	15	4	0.30
46	4	8	12	16	41	18	1	0.21
47	5	11	14	14	17	33	6	0.19
48	5	14	19	19	20	15	8	0.32
49	6	12	13	15	28	19	7	0.22
50	8	15	17	15	11	28	6	0.32
51	8	11	14	16	21	23	7	0.25
52	5	12	18	21	22	15	7	0.29
53	7	11	15	15	22	23	7	0.23
54	7	16	18	25	20	13	1	0.38
55	8	11	16	14	27	16	8	0.24
56	7	14	13	17	15	28	6	0.26
57	5	8	11	12	24	26	14	0.16
58	8	13	13	14	20	26	6	0.23
59	6	8	12	11	19	31	13	0.15
60	5	9	12	17	18	22	17	0.24
61	8	10	15	14	21	24	8	0.23
62	7	11	15	15	24	20	8	0.24
63	3	10	13	18	22	23	11	0.19
64	4	6	21	18	31	19	1	0.24

Sample localities (T: town, V: village):

- |                                           |                                   |
|-------------------------------------------|-----------------------------------|
| 33. Do.                                   | 49. Nakagawa, Shimo-ijuin V.      |
| 34. "Asahi" tunnel, Higashi-ichiki T.     | 50. Do.                           |
| 35. Do.                                   | 51. Mugiuda, Shimo-ijuin V.       |
| 36. Tashiro, Higashi-ichiki T.            | 52. Do.                           |
| 37. Kaida, Higashi-ichiki T.              | 53. Koyamada, Kagoshima City      |
| 38. South of Eguchiura, Higashi-ichiki T. | 54. Do.                           |
| 39. Tataraguchi, Higashi-ichiki T.        | 55. Nakafukura, Koriyama V.       |
| 40. Kakinosako, Higashi-ichiki T.         | 56. Take, Koriyama V.             |
| 41. Eguchiura, Higashi-ichiki T.          | 57. Hirabaru, Koriyama V.         |
| 42. Do.                                   | 58. Yusuki, Koriyama V.           |
| 43. Western Kakinosako, Higashi-ichiki T. | 59. Nasubida, Koriyama V.         |
| 44. Nagasato, Higashi-ichiki T.           | 60. Do.                           |
| 45. Do.                                   | 61. Higashi-koriyama, Koriyama V. |
| 46. Shibaidan, Higashi-ichiki T.          | 62. Yamada, Shimo-ijuin V.        |
| 47. West Koriyama, Koriyama V.            | 63. Eguchiura, Higashi-ichiki T.  |
| 48. Do.                                   | 64. Do.                           |

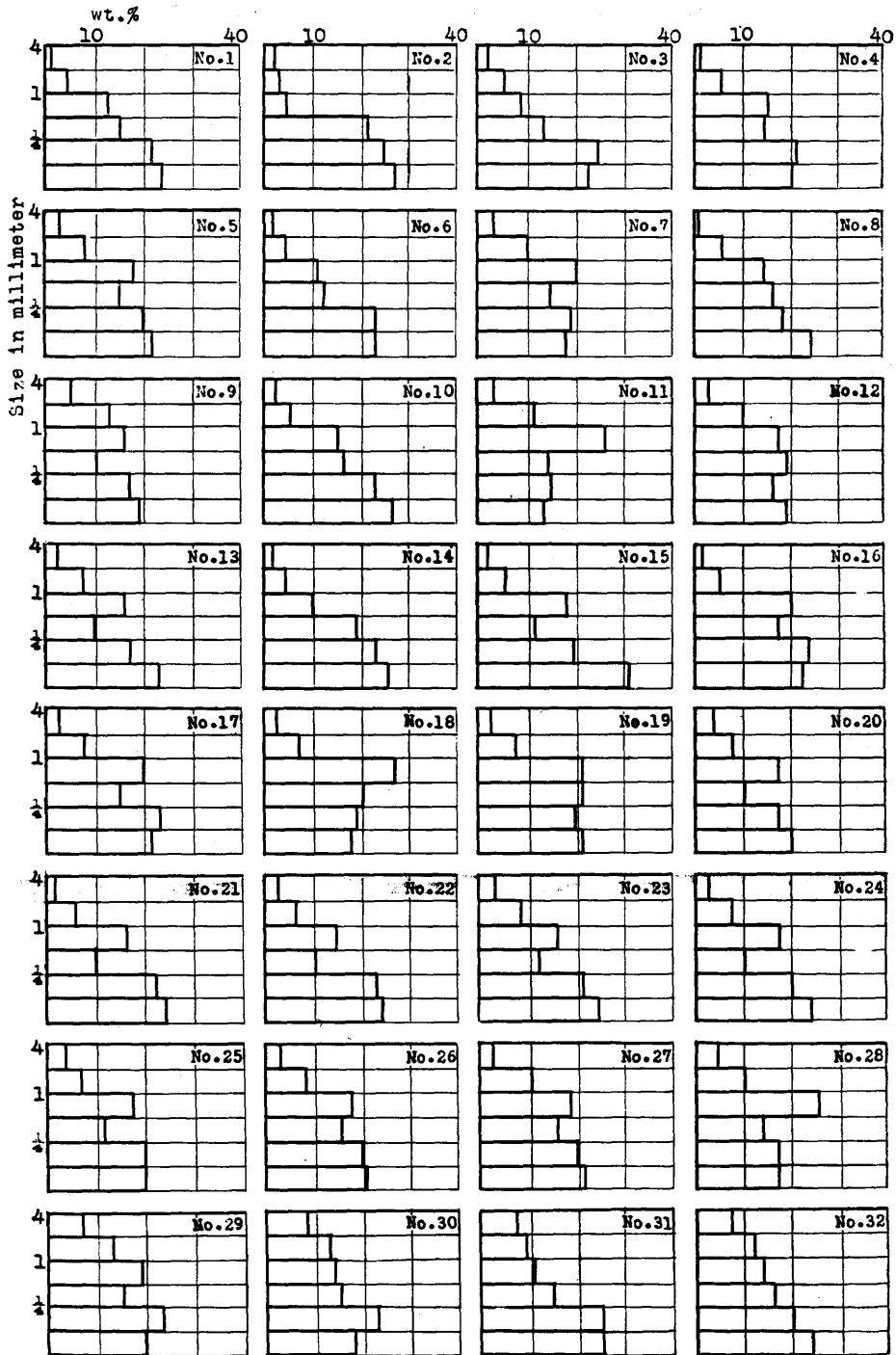


Fig. 6a. Histograms for the "Shirasu" (Fragments larger than 4 mm. in diameter are excluded)

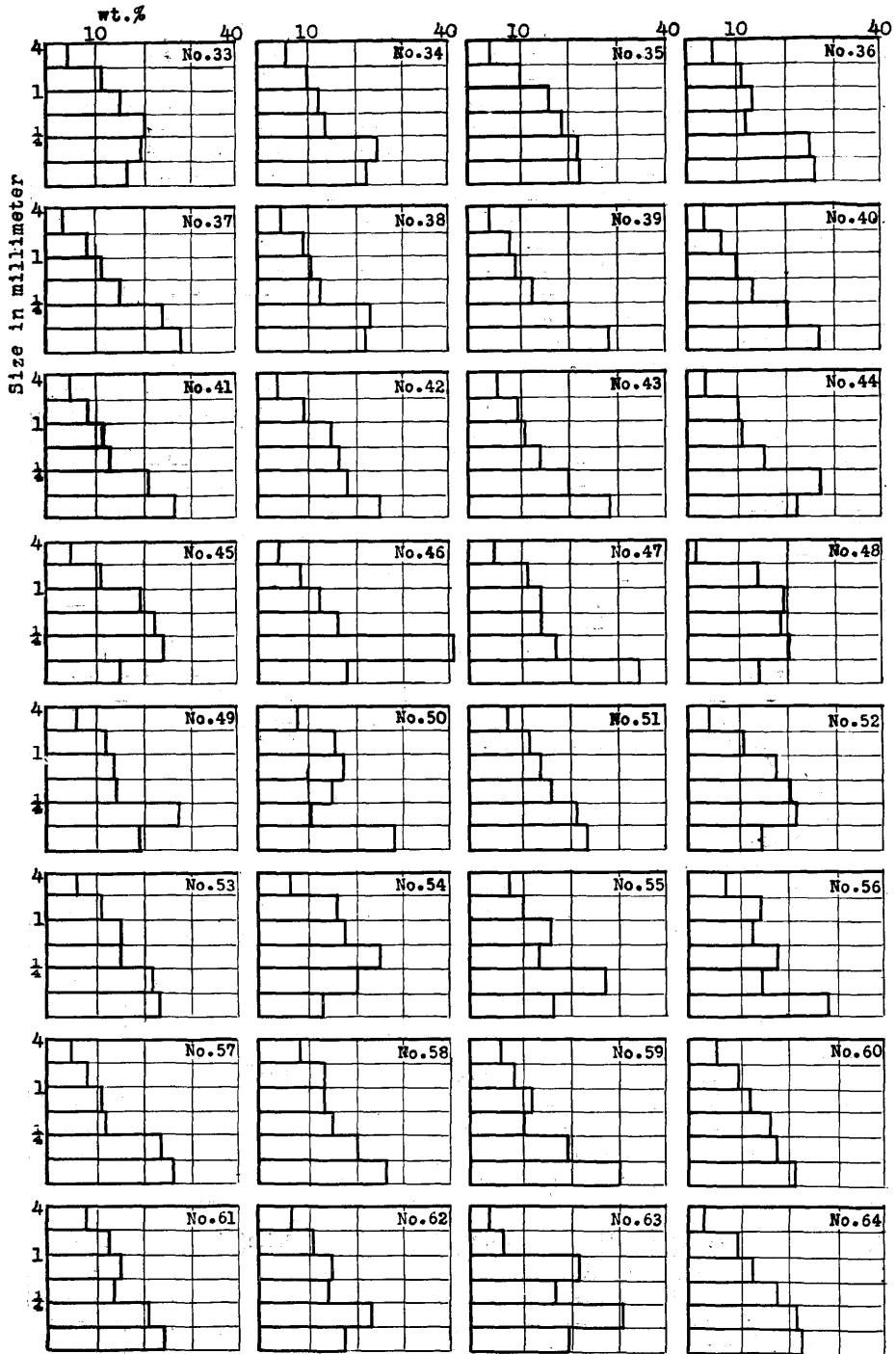


Fig. 6b. Histograms for the "Shirasu" (Fragments larger than 4 mm. in diameter are excluded.)

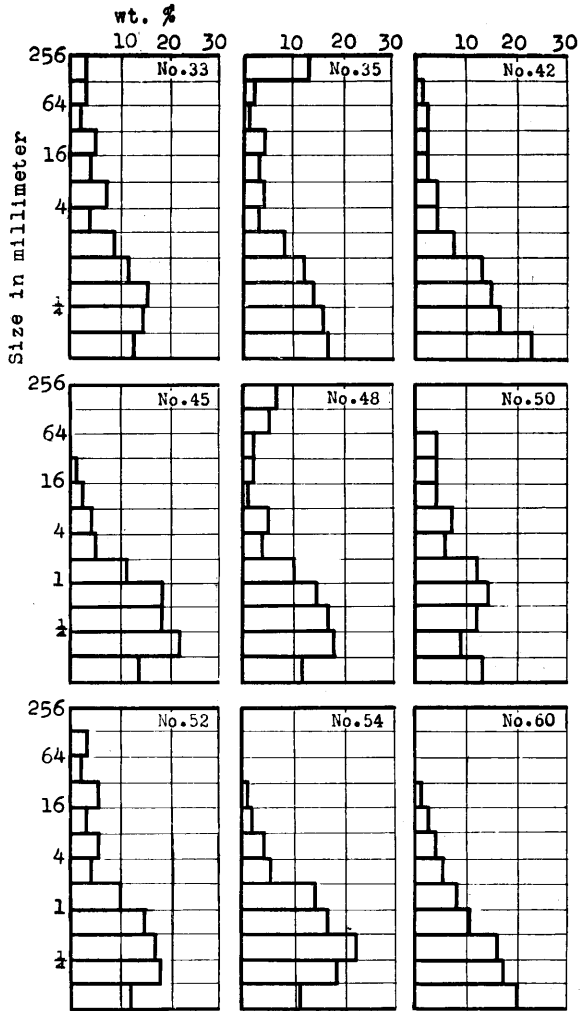


Fig. 8. Histograms for the "Shirasu" (The whole "Shirasu"; including large fragments over 4 mm.)

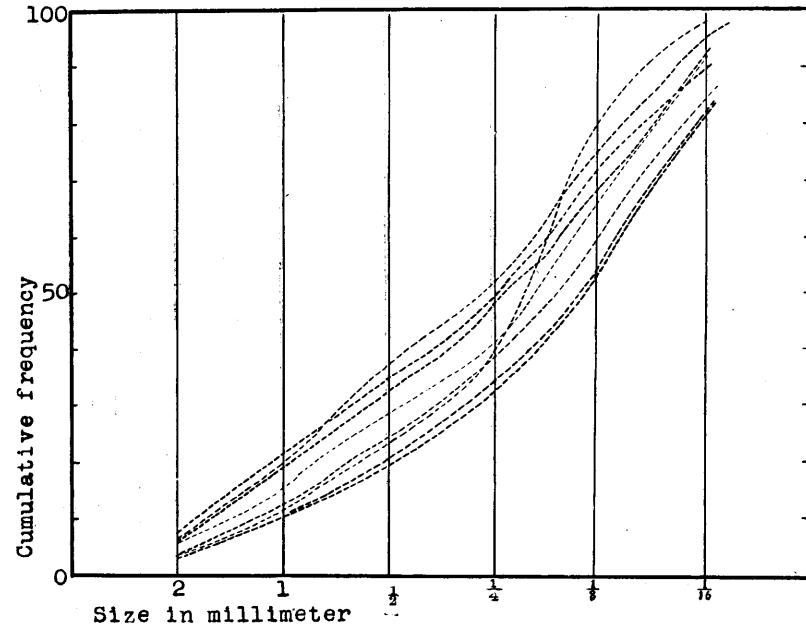


Fig. 7. Cumulative Curves for the "Shirasu"  
(Refer to Figs. 6a & 6b)

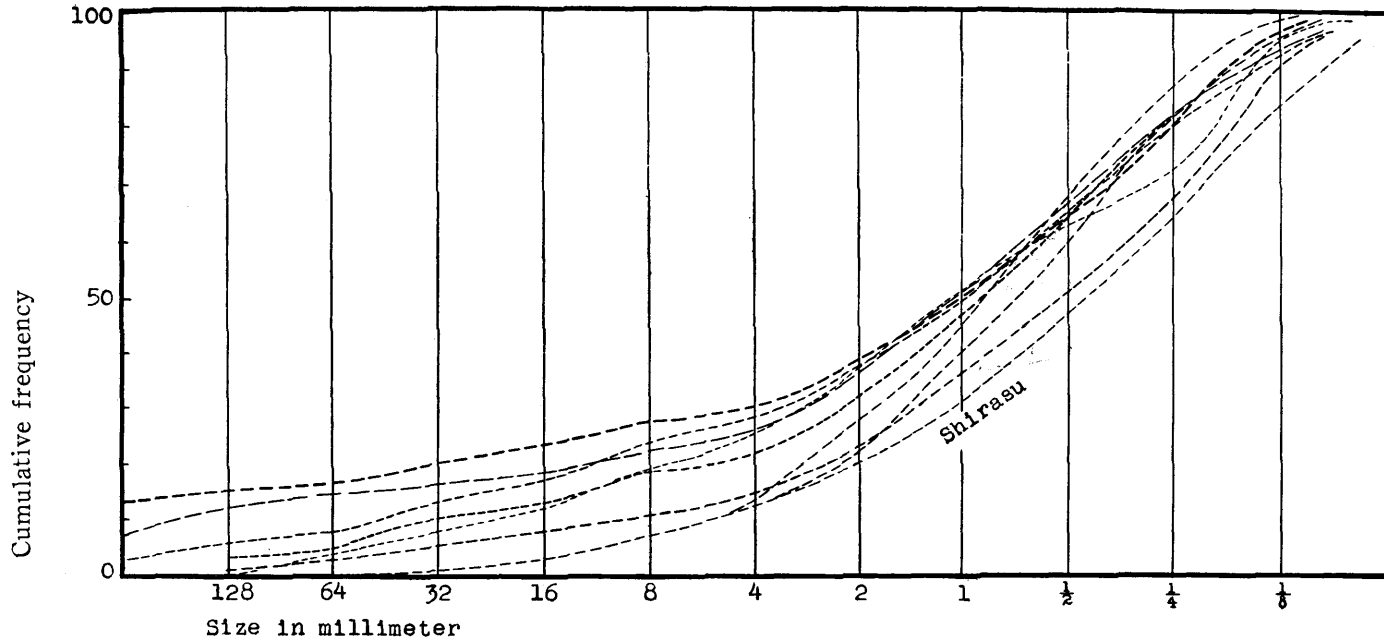


Fig. 9. Cumulative Curves for the "Shirasu" (Refer to Fig. 8.)

Table 4. Size distribution of the whole "Shirasu," including large fragments exceeding 4 mm diameter  
(Nos. refer to Table 3)

No.	256-128	128-64	64-32	32-16	16-8	8-4	4-2	2-1	1-1/2	1/2-1/4	1/4-1/8	1/8-1/16	1/16>	wt. %
													mm.	
33	3	3	2	5	4	7	4	9	12	16	15	13		7
35	13	2	1	4	3	4	3	8	12	14	16	17		3
42	—	1	2	2	2	4	4	8	13	15	17	23		9
45	—	—	—	1	2	4	5	10	18	20	22	14		4
48	7	5	2	2	1	5	4	11	15	15	16	12		6
50	—	—	4	4	4	7	6	12	14	12	9	23		5
52	—	3	2	5	3	5	4	10	15	17	18	12		6
54	—	—	—	1	2	4	6	15	17	23	19	12		1
60	—	—	—	1	2	4	5	8	11	16	17	20		16

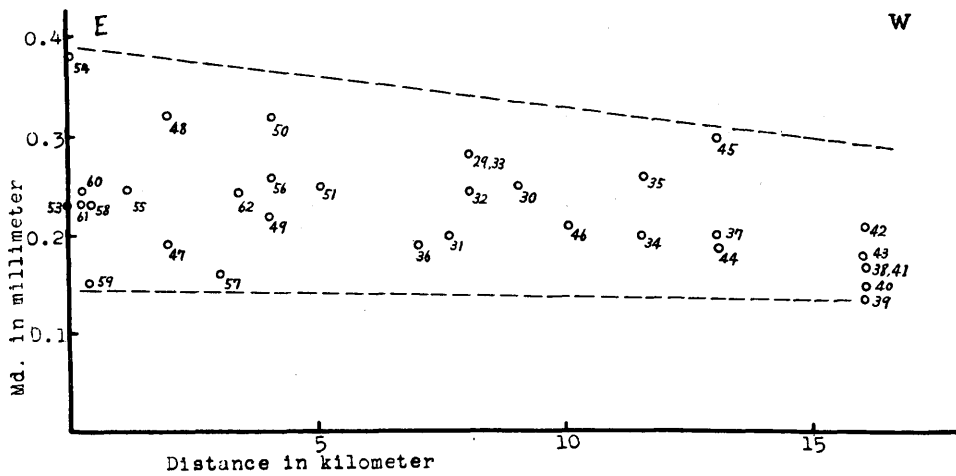


Fig. 10. Variation of Md. along the line between Koyamada and Eguchiura (Nos. refer to Table 3.)

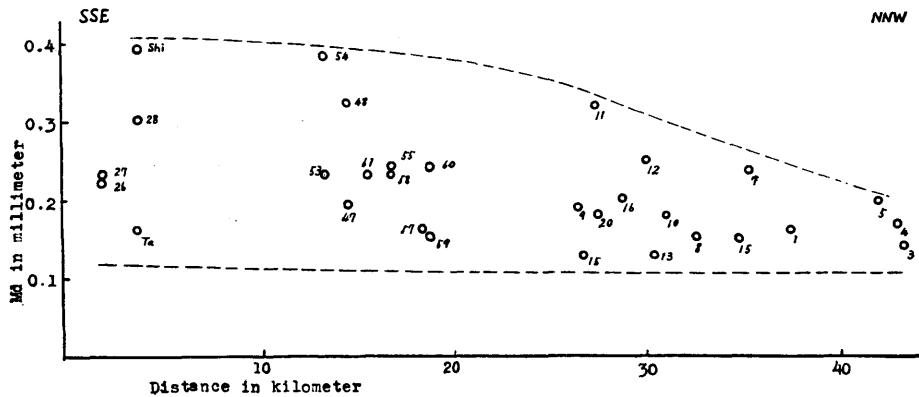


Fig. 11. Variation of Md. along the line between Kagoshima City and Miyanojo Town. Shi: Shiroyama, Kagoshima City. Ta: Tagami, Kagoshima City. (Nos. refer to Table 3.)



2. *Median diameter.* Median diameter (Md) is not constant, so far as the data listed in Table 3 show, ranging from 0.38 to 0.14, averaging 0.21, and no regularity in its variation is observed. As regards the maximum value of Md, however, there is a tendency that it is higher around Kagoshima City, decreasing towards the north-north-west (Figs. 10, 11).

3. *Size classification of the "Shirasu".* The histograms for the "Shirasu" are classified into three type as shown in Fig. 12. These types are used as the basis for size classification of the "Shirasu" (Table 5). To find out some relationship between the distribution of the three types and the topography or the geology of this area, all sample localities of each type were plotted on the geological and topographical maps, but in vain (Fig. 13).<sup>3)</sup>

Table 5. Size classification of the "Shirasu"

Type	Sample numbers	Total	Sum total
I	4, 5, 7, 9, 11, 12, 13, 15, 16, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 36, 48, 50, 55, 56, 59, 61, 62, 63	30	64
II	1, 2, 3, 6, 8, 10, 14, 18, 30, 31, 32, 33, 34, 35, 37, 38, 45, 51, 52, 53, 54, 57, 58, 60, 64	25	
III	39, 40, 41, 42, 43, 44, 46, 47, 49	9	

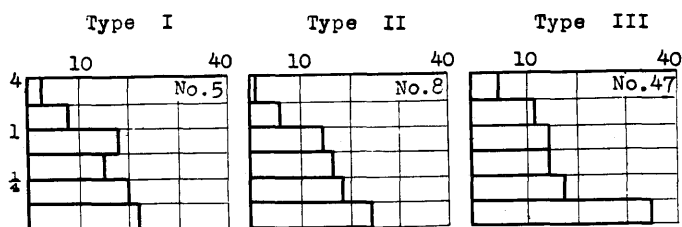
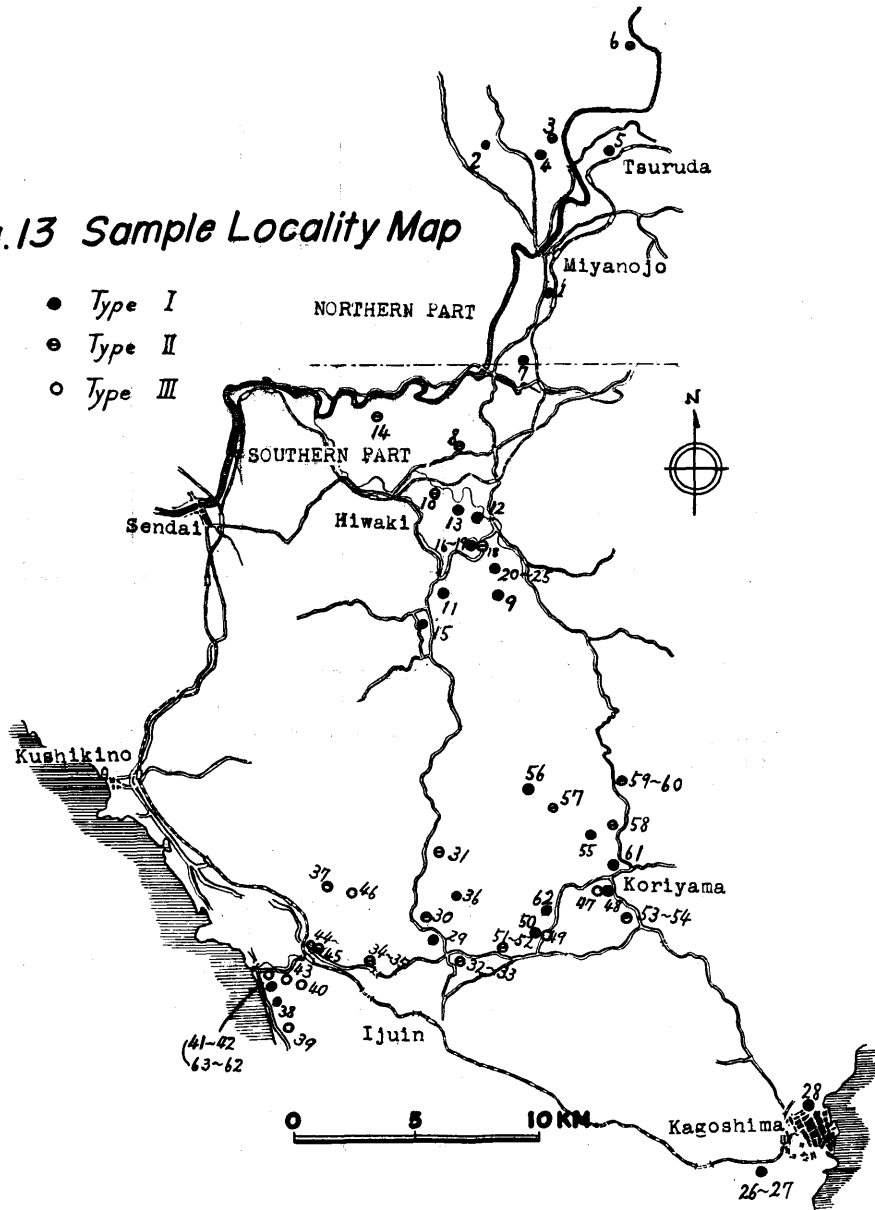


Fig. 12. Three types of histograms.

4. *Size variation in cumulative curve.* In order to know the limit of the area of constant size-distribution, 28 samples taken within an area of 20 m square at Eguchiura, Higashi-ichiki Town, were mechanically analysed and the results are shown in Fig. 14 a, which reveals that the difference in variation is so slight as to be almost negligible so far as a small area as much as 20 m square is concerned. As for a full discussion on the vertical variation no suggestion had ever been observed, but the six samples from a cliff in Hiwaki Town (Table 3 and Fig. 6, Nos. 20-25) have now revealed that this variation should not be so large.

3) It seems that in the area bordering North Kagoshima Bay on the north-west (viz., the Koriyama-Ichihino area) each type is predominating at separated places, while this is not clear in the area remote from North Kagoshima Bay (i.e., the Tsuruda-Yamasaki area).

**Fig.13 Sample Locality Map**



Then we compared the size distributions of the "Shirasu" of the same horizon from two localities, 100 m apart from each other, in Eguchiura; at each locality, seven samples were analysed. The somewhat distinguished difference in size distribution between the two localities (Fig. 14, a and b) is not so remarkable in view of the range of variation of the "Shirasu" in the Tsuruda-Hiwaki-Koriyama area.

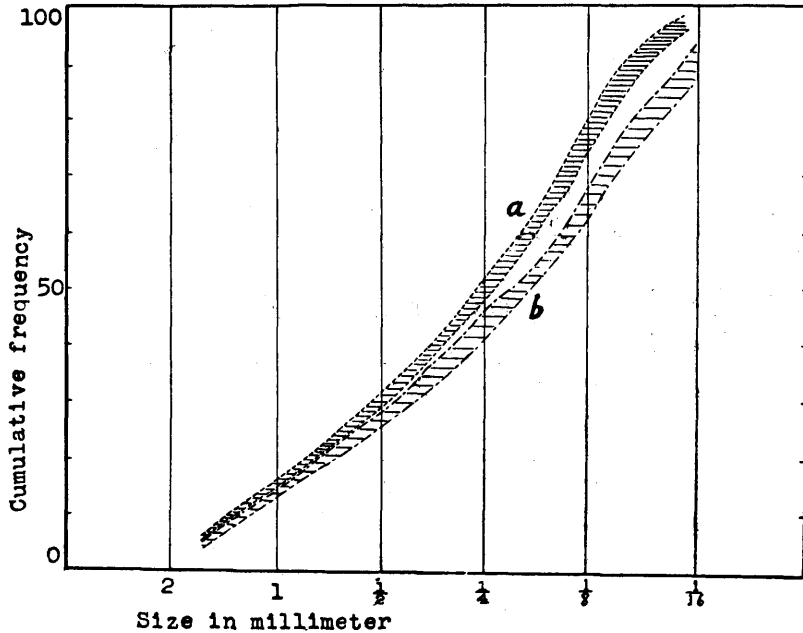


Fig. 14. Variation in Size distribution for the "Shirasu" from Eguchi-ura, Higashi-ichiki Town.

- a: range of size distribution of 28 samples from the cliff A.  
 b: range of size distribution of 7 samples from the cliff B, 100 m south of the cliff A.

#### Proportion of Component Minerals

The principal component minerals of the "Shirasu" are plagioclase, hypersthene, augite, hornblende, quartz, and magnetite (Table 6). The proportions of the minerals of varying grain-size in two samples from Tagami, Kagashima City, and Eguchiura, Higashi-ichiki Town, were measured with the results as shown in Table 7 and Fig. 15. At a glance we can see (1) the relationship between the proportion of the minerals and their grain-size, and (2) the maximum dimension of each mineral.

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Table 6. Mineral contents in the "Shirasu" and "Hai-ishi"

		glass	pl	hy	au	ho	Others
"Shirasu"		○	○	○	■	●	Quartz Magnetite
"Hai-ishi"	Upper	○	○	○	■	×	
	Middle	○	○	○	■	■	Chloritic minerals
	Lower (A)	○	○	■	■	×	
	Ditto (B)	○	○	■	×	×	
	Ditto (C)	○	○	■	■	■	

○ abundant    ■ poor    ● very poor    × non

Table 7. Size distribution of minerals of the "Shirasu"  
(in weight %)

Mesh Min.	Mesh									
	10	20	32	48	60	100	150	200	250	250>
(a)										
Gl	7.33	7.52	5.44	9.79	5.31	12.30	11.70	7.90	2.98	7.97
F & Q*	0.67	8.32	6.12	3.62	0.54	0.57	0.17	0.03	tr.	tr.
hy	—	0.16	0.41	0.55	0.11	0.09	0.06	} 0.04** 0.01** ?		
au	—	—	—	tr.	0.005	tr.	tr.			
ho	—	—	—	0.02	0.007	tr.	0.03			
mt	—	—	—	0.06	0.04	0.075	0.06	0.03	0.01	0.03
(b)										
Gl	4.88	6.62	5.90	7.80	6.91	17.50	16.70	8.35	2.14	0.38
F & Q*	0.23	6.86	5.95	3.80	1.21	0.37	1.37	0.08	—	—
hy	—	0.14	0.32	0.51	0.20	0.17	0.05	} 0.20** — —		
au	—	—	—	tr.	0.02	0.04	0.04			
ho	—	—	—	0.04	0.03	0.06	0.04			
mt	—	—	—	0.10	0.08	0.13	0.05	—	—	—

(a) 54813: Tagami, Kagoshima City (b) 64: Eguchiura, Higashi-ichiki Town

\* Quartz is abundant in 60, 100, and 150 meshes.

Total:	(a)	(b)
Gl (glass) .....	78.24	77.18
F & Q .....	20.04	20.23
hy (hypersthene) .....	1.38	1.39
au (augite) .....	0.005	0.10
ho (hornblende) .....	0.057	0.17
mt (magnetite) .....	0.315	0.36
** .....	0.05	0.20
	<u>100.087</u>	<u>99.63</u>

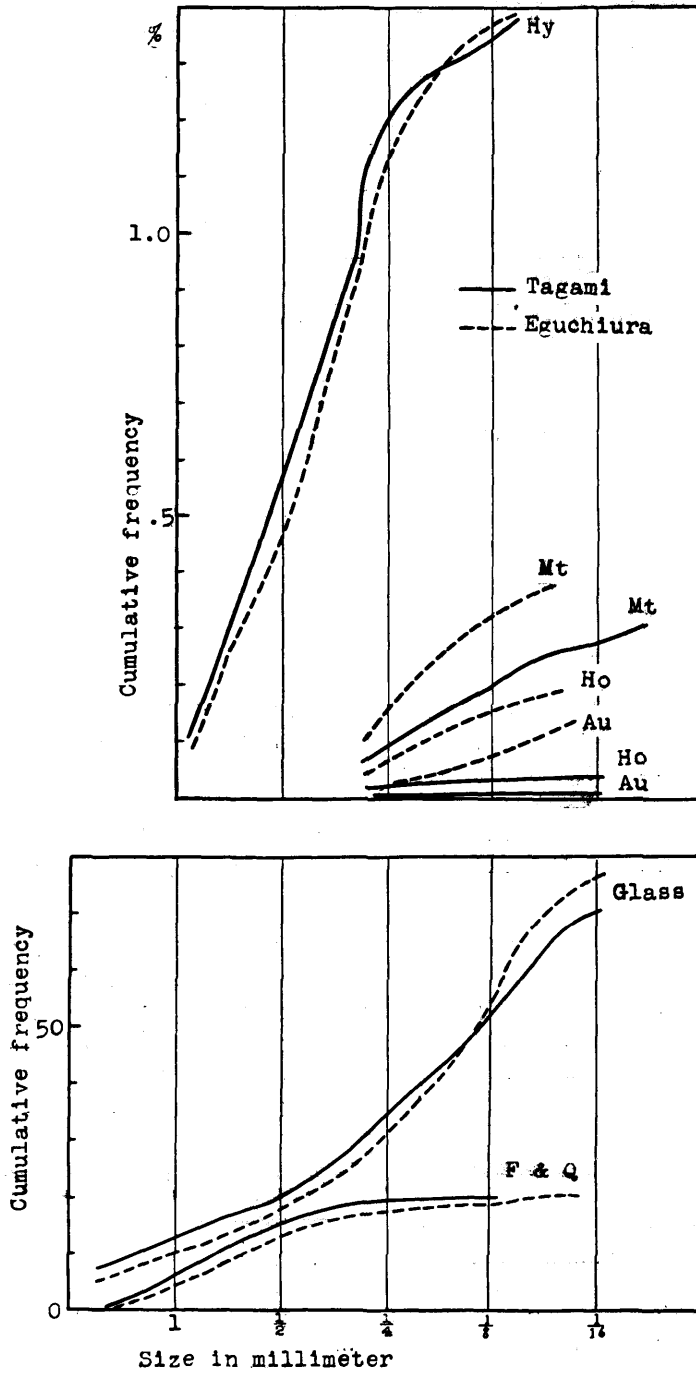


Fig. 15. Size distribution of minerals in the "Shirasu"

**References Cited**

- MOORE, B. N. (1934). Deposits of Possible Nuée Ardente Origin in the Crater Lake Region, Oregon. *Jour. Geol.*, 42, 355-375.
- TANEDA, S. (1954). Geological and Petrological Studies on the "Shirasu" in South Kyushu, Japan. Part I. Preliminary Note. *Mem. Fac. Sci., Kyushu Univ., Geology*, 4, 2, 167-177.
- (1957). Geological and Petrological Studies of the "Shirasu" in South Kyushu, Japan. Part II. Preliminary Note (2). *Ditto*, 6, 2, 91-105.