On the Creation of the Suribachi at Iwanai.

By

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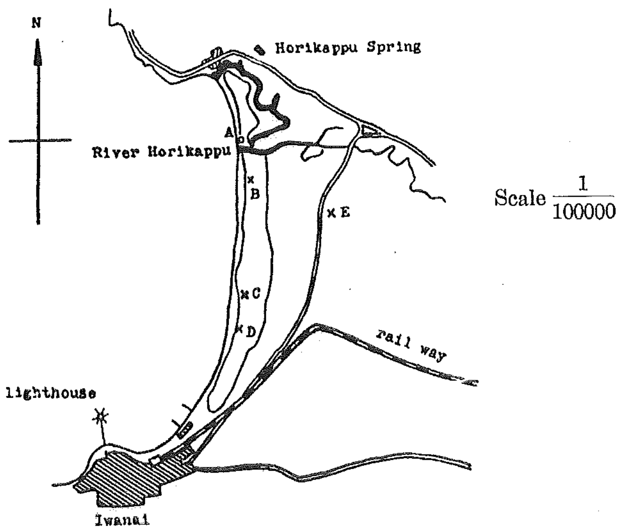
Introduction.

There is a long chain of dunes running from north to south along the sea shore through the 7 km. length of Riyamunai beach in the vicinity of Iwanai which is situated in the western part of Hokkaido. One can easily find several dozens of U-shaped circular holes scattered here and there on these sand dunes as shown in Fig. 2. These holes seem to belong to the same category of so-called Suribachi on which Dr. TOKUDA has written in Japanese in the Tisitugakuzassi[1].



Map of the coast line at Riyamunai, showing the situation of the Suribachis.

Fig. 1.

Therefore the holes of this sort scattered in the sand dune zone may be called Suribachi after Dr. TOKUDA.

(1) T. TOKUDA: Tisitugakuzassi, Vol. 24, (Taisyo 6) No. 280, p. 6.

View seen from the northern side of the circumference of the Suribachi at point D.

Fig. 2.

During a two week stay in the summer of 1935 at the beach of Riyamunai where the measurement of the propagation velocity through sand was first undertaken under the guidance of Prof. Y. IKEDA, in spare moments rough and rapid observations on these holes could be made.

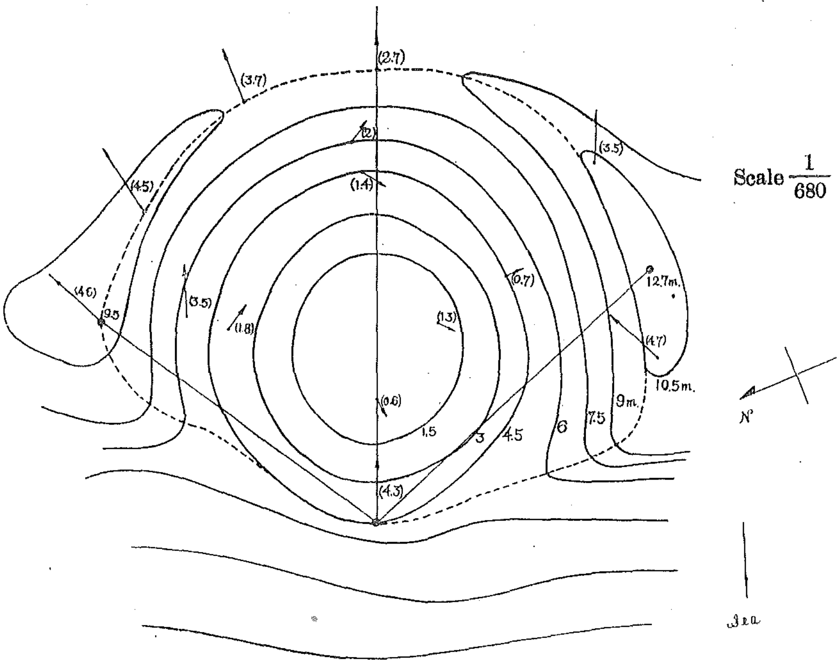
The materials obtained by these rough observations will not lead to satisfactory conclusions on the constitution and formation of these Suribachi. However, the process of the creation of the Suribachi can be imagined, though it may be only imperfectly.

1. The shape of the Suribachi.

In order to determine the shape of Suribachi, a plane table survey was made. The results are shown in Fig. 3.

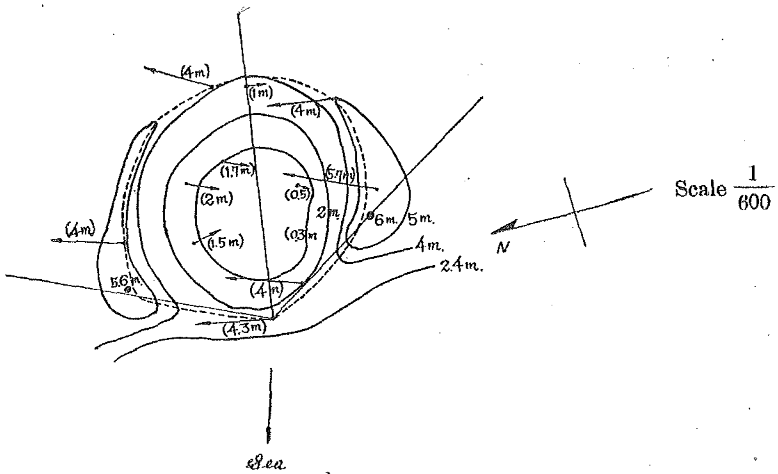
The wind velocity and its direction at several points in the neighbourhood of the Suribachi was measured by a small anemometer with vane. The results are included in Fig. 3 where the direction of the arrows and numbers written in parentheses beside the arrows indicate respectively the direction and the velocity of the wind.

A line connecting the peaks of these dunes is parallel to the sea shore and at 80 m distance from it. The angle of the slope of dune toward the sea shore is so great that it reaches about 45°. The formation of such a steep slope may be explained as due to the fact that the sand grains are tightened by a suitable water content and by spreading out of plant roots in the sand.



a.

Suribachi at point D.



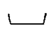
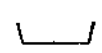
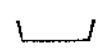
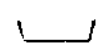
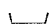
b.

Suribachi at point C.

Fig. 3.

Some data on the size of Suribachi at Iwami District, Tottori Prefecture taken from Tokuda's paper are summarized with data from Iwanai in the following table.

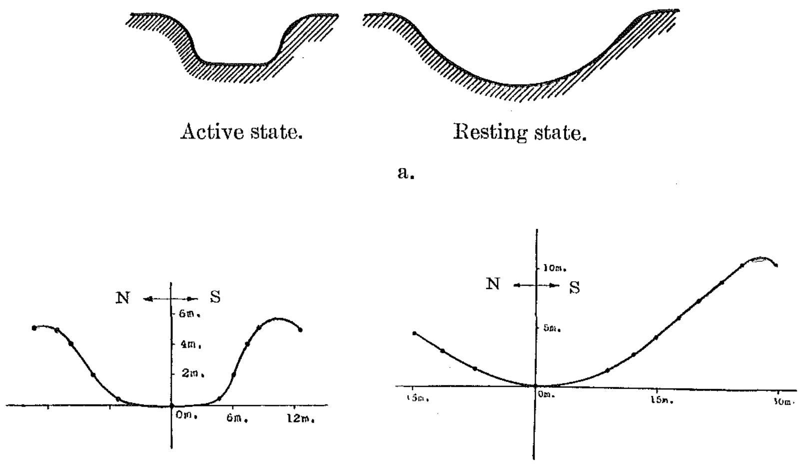
Table 1.

No.	Name	Place	Depth H in m.	Diameter of Hole		$\frac{d_0-d_i}{d_0}$	Form of Hole
				Dia. of periphery d_0 in meters	Dia. of base d_i in meters		
1	Hosokawa Suribachi	Hosokawa, Iwami District, Tottori Prefecture	7	—	—	—	
2	Hutatuyama Suribachi	Hutatuyama, Iwami District, Tottori Prefecture	8	—	—	—	
3	Tanê Suribachi	Northern part of Tanegaike, Iwami District, Tottori Prefecture	14	70	30	0.57	
4	Nisi-Tanê Suribachi	Western part of Tanegaike, Iwami District, Tottori Prefecture	7	—	—	—	
5	Hamasaka Suribachi	Northern part of Hamasaka, Iwami District, Tottori Prefecture	12	40-50	7-8	0.83	
6	Higasi-Hamasaka Suribachi	Eastern part of Hamasaka, Iwami District, Tottori Prefecture	6	—	—	—	
7	Suribachi at point C	Riyamunai beach, Iwanai District, Hokkaido	5.5	20	10	0.50	
8	Suribachi at point D	Riyamunai beach, Iwanai District, Hokkaido	10	48	6	0.88	
9	Suribachi at point B	Riyamunai beach, Iwanai District, Hokkaido	—	—	—	—	
10	Hamanaka Suribachi at point E.	Hamanaka, Maeda Village, Iwanai District, Hokkaido	5	45-50	7	0.85	

Tokuda estimated the size of the Suribachi at Hamasaka ten years before the time of his photograph to have been 13–15 m. in depth and

20 m. in diameter at its base. This decrease of the base area during ten years shows the decay of Suribachi. His Suribachi No. 3 seems to be also in the resting state. From his paper it is evident that the difference between d_0 and d_i at other Suribachi except (3) and (5) has a very small value which is not shown numerically in his paper.

The profile curves of the vertical section of the Suribachis in N-S direction are constructed from Fig. 3. The results are shown in b and c of Fig. 4. As is evident from the observation at



Active state. Resting state.

a.

Suribachi at point C. Suribachi at point D.

b. c.

The profiles of Suribachis in north-south direction.

Fig. 4.

Iwanai, in the old stage of a Suribachi d_i is so small compared with d_0, that $\frac{d_0-d_i}{d_0}$ will approach to 1. From these observations the quantity $\frac{d_0-d_i}{d_0}$ may be considered as the measure of the age of Suribachi. This fact is easily shown by the profile of Suribachi as shown in Fig. 4. From the forms of the Suribachi it can be easily judged whether they are in active state or in resting state. Fig. 4 a shows the cross section of a Suribachi in active state, while Fig. 4 b that of one in resting state. Figs. 5 and 2 respectively show photographs of Suribachi at C (active) and D (resting).

View from the south-western part of the circumference of the Suribachi at point C, looking toward the east part of the inner surface of the same Suribachi.

Fig. 5.

2. The wind velocity and its direction at Iwanai.

The data on the wind velocity at this place are taken from the synopsis of the Kayanuma Coal Mine Co. As the season when sand grains fly in the wind at this place extends from April to October every year, the data are taken during these months from 1920 to 1930.

According to the results of the experiment with the dune model by Mr. ARAMATA(2), the transported quantity of sand Q by wind of uniform velocity is estimated approximately by the following formula.

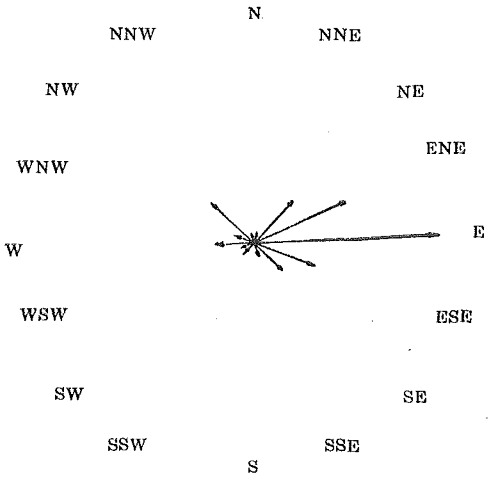
$$Q = k(v-7)t$$

where v is the wind velocity in m/sec.
t is time in sec.

Assuming t constant, $v-7$ may be taken as the measure of the sand transport. As this measure may be superposed, the magnitude of the same direction can be superposed. From the synopsis above described the days of the greater values than 7 m./sec. of daily maximum velocity of the wind at Iwanai are chosen and classified

(2) M. ARAMATA, On Formation of Dune. Mem. Fac. Eng., Hokkaido Imp. Univ., Vol. 4, No. 3, p. 296 (1938).

in accordance with the wind direction. The results are tabulated in Table 2 and vectorially shown in Fig. 6. From this polar diagram, the directions and magnitudes of the winds at this place may be readily seen.



Polar diagram of the wind direction at Iwanai.
Fig. 6.

Table 2.

W	WNW	NNW	E	S	WSW
7.0	6.6	9.8	7.4	4.3	7.0
4.1	9.8	(9.8)	5.6	(4.3)	2.6
6.3	3.5		3.4		2.2
10.0	2.6	NE	3.7	SSW	10.5
3.5	1.4	11.2	6.3	7.5	7.0
4.2	12.4	(11.2)	(26.4)	(7.5)	11.7
5.3	11.3				10.5
4.8	(47.6)	ENE	SE	SW	7.7
0.4		4.2	9.0	6.6	12.7
12.9	NW	2.6	3.2	10.1	(71.9)
5.1	4.1	2.6	18.2	4.6	
11.5	5.7	(9.4)	2.1	9.1	
9.2	7.0		3.7	11.3	
7.5	5.9	ESE	4.5	(41.7)	
15.4	6.3	12.6	(40.7)		
14.0	(29.0)	(12.6)			
7.5					
(128.7)					

It is reasonable to suppose that striking topographical changes in the neighbourhood of the dunes took place on the days of maximum wind velocity during one month.

From the same data, the frequency of the wind with a larger velocity than 7 m/sec is reckoned on every 1 m/sec with results shown in table 3.

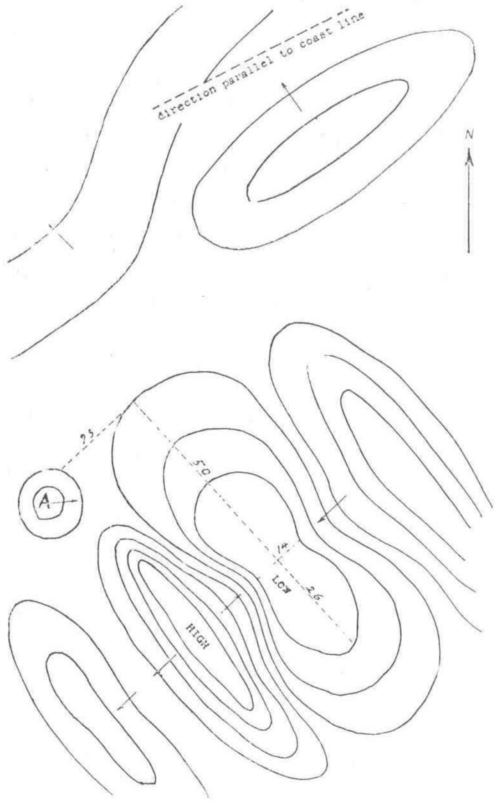
If we take $v-7 = 12$ (m/sec) as the most probable upper limit of maximum velocity of the wind, v becomes 19 m/sec.

Table 3.

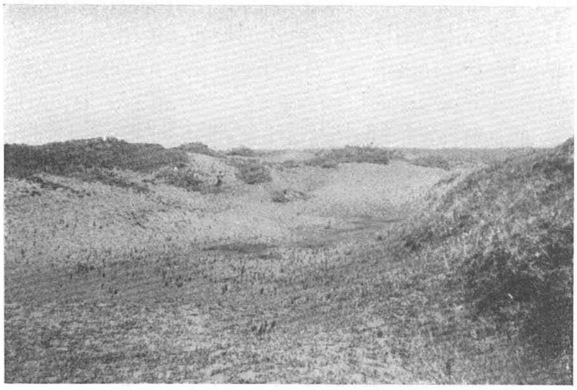
(V-7) m/sec.	Frequency	(V-7) m/sec.	Frequency
0	1	10	4
1	1	11	5
2	6	12	4
3	6	13	0
4	8	14	1
5	5	15	1
6	5	16	0
7	8	17	0
8	0	18	1
9	4	19	0

3. Creation of Suribachi.

In this region, the winds from W, NW and SW are strongest as shown in Fig. 6. Of these three, the wind W whose directions is nearly at a right angle to the coast line necessarily forms the dunes but is not so important a factor as the other two in the formation of Suribachi. If the direction of the wind is confined to one, such a beautiful hole will be not found there. Such typical examples of Suribachi are found on the dunes along the beach from Isikari to Zenibako. They are rather narrow and long to the direction parallel to that of the predominant wind as shown in Fig. 7.



Map of Suribachi near Isikari.
Fig. 7 (a).



View from point A of Fig. 7 (a), looking in the south-westerly direction.
Fig. 7 (b).

When a SW wind strikes the northern small hill and is changed in direction by this hill, the stream of air is divided into several parts which flow along the paths shown in Fig. 8.

When the SW wind is so violent that the velocity of the air flow inside the Suribachi is over 7 m/sec, the sand is excavated from the inner surface of the Suribachi and is blown up at the south-western corner of the Suribachi to form a small hill.

The mixed flow of air and sand circulates clockwise along the circumference of the hole. Path (3) passes almost at the bottom and the sand is blown up on the opposite southern hill. These motions of the sand have been observed by Prof. Y. Ikeda himself on a windy day of June, 1935.

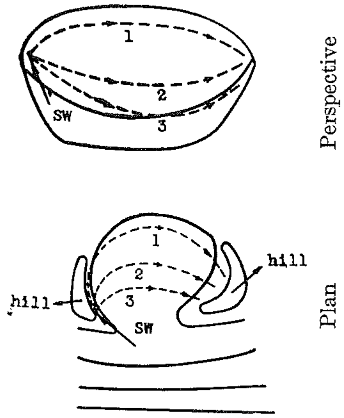


Fig. 8.

When a NW wind blows, the flow of air and sand becomes opposite to that in the case of the SW wind. But the SW wind is more violent than the NW so that the southern hills are higher than the northern hills at any one of the Suribachis at Iwanai. The small side hill of a Suribachi in sctive state is longer compared with that of one in the resting state. The hill of the latter is so small that the greater part of the NW and SW winds pass over. The existence of the upper limit of the wind velocity, for example that at Iwanai is estimated as 19 m/sec, is described in the preceding article. Initially the Suribachi is gradually enlarged even by a slight wind. The diameter is rapidly or slowly enlarged by the high or low wind velocity. The size of an excavated Suribachi which has reached a certain value as a result of the latest and largest wind V_1 will never be enlarged by a wind of smaller velocity than V_1.

However, the d_1 diameter of the Suribachi will be enlarged by a wind of larger velocity V_2 than V_1. If this wind continues for a long time, d_1 will become d_2. If the wind of this value becomes calm for some time, d_1 will not become d_2. The wind of a larger velocity than a certain value at one place seldom occurs.

After a long time has elapsed, the inner surface of a Suribachi is covered with luxuriant vegetation till the sands of the surface will not be excavated even by a heavy wind. Thus the agency of enlargement will become impotent and finally the Suribachi will enter the resting state.

Summary.

The shape of the Suribachi which was quantitatively measured by the plane survey was studied in relation with the predominant winds from three directions at this place. From the comparison between these two, the process of the creation of the Suribachi, can be imagined, though it may be imperfect. At the same time, the degree of the activity of the Suribachi can be easily estimated from the profile of the cavity.

In conclusion, the writer wishes to express his best thanks to Professor Y. IKEDA for valuable suggestion and kind guidance and also to Messrs. M. MORI and M. ARAMATA who gave many useful materials.

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