On the Mechanism of the Formation of the Syowa New Mountain

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where the seismometer was set. It is not yet clear whether this stratum is a Toyoura-Bed or weathered rhyolite. But we must at least deny the existance of the cryptodome, the

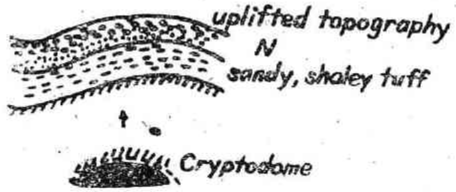

Fig. 7.

group of andesite and rhyolite, under the "Roof mountain" at least to a point 150m from the surface. The "Roof mountain" is only an uplifted plateau formed with the gush of the central dome. On the other hand, the existance of a dome structure must be reckoned with somewhere deeper in the underground structure in the gradual uplifted zone near Yanagihara, as illustrated in FIg 7.

We wish to use this opportunity to thank Mr. S. Imai for his useful assistance throughout this investigation.

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ON THE MECHANISM OF THE FORMATION OF THE SHOWA NEW MOUNTAIN OF USU VOLCANO, HOKKAIDO, JAPAN.

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A new parasitic volcano appeared on the west side of volcano Usu, Hokkaido, Japan in 1944, the 19th. year of Showa. To the end of 1943 many small earthquakes were felt and an area of 2 km² near Yanagihara in the valley of the river Sobetsu was raised since the beginning of 1944. After the upheaval in this area nearly ended, another area a little north of Yanagihara and west of Fukaba began to rise in June of 1944. (see Fig. 1).

On June 23, 1944 when the upheaval reached 50m or more, eruptions took place on the top of the elevated area. The upheaval continued further forming a hill of about 150m above its original level with craters on its top.

On 20th. Dec. 1944 Mr. Masao Mimatsu, the

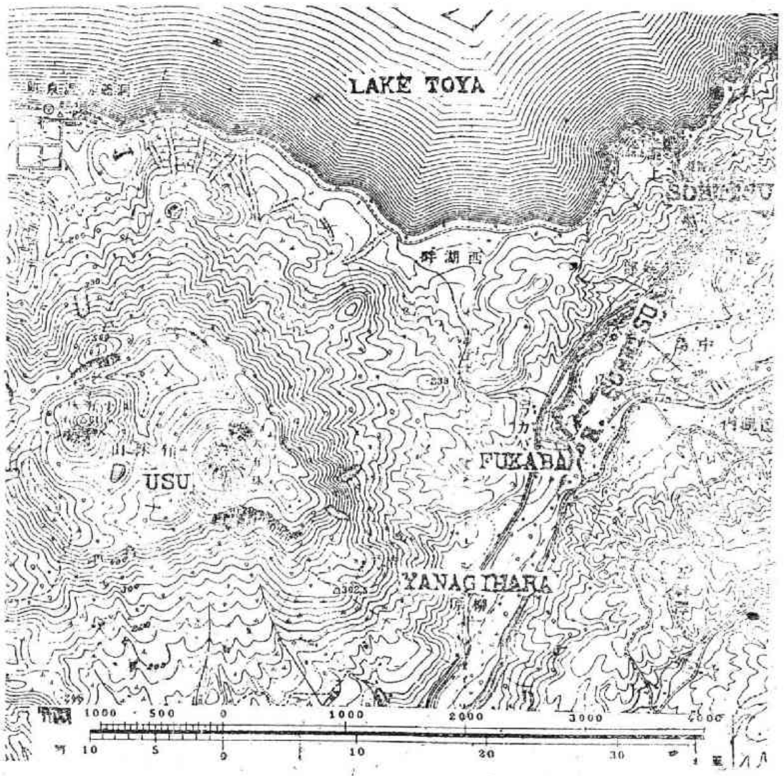

Fig. 1

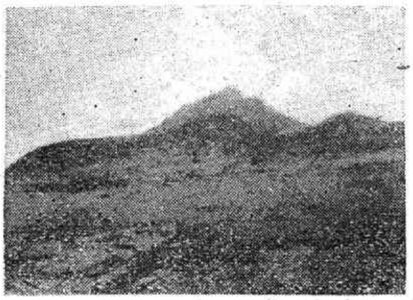

Fig. 2
North side of the new mountain.

chief of the post office of Sobetsu, first found the peak of the dome on the steaming top of the hill, so called the roof mountain. The dome continuary grew up and meanwhile the upraised area extended to the east and at last it reached the village of Fukaba and pushed it up and destroyed it.

After the map of Mr. Ziro Okamoto made in 1946-1947, the central dome is 405m and the roof mountain is about 250m high above the sea level. Fig. 2 is the view of the northern side of the mountain. Every steps of the growth of the mountain is well traced back in the sketches made by Mr. Mimatsu (see Fig. 3).

The writers made some model experiments and calculations to reveal the mechnism of the formation of the mountain. A small iron bar is pushed up from the bottom of a layer of fine sand, 0.2-0.5 mm in diameter. The upper end of the bar is conical or flat. The bar is moved vertically or obliquely. Fig. 4 shows the case of vertical movement of the bar with the conical end. In this case, the roof mountain is first formed (Fig. 4 a) and then the end of the bar, which imitates the dome

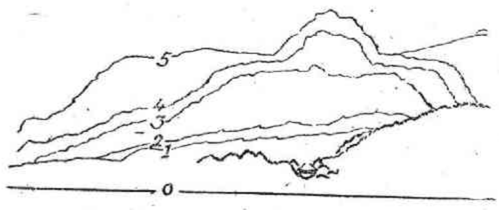

Fig. 3 Mimatsu's sketches of the new mountain.
0 ...... Horizon
1 ...... Original ground surface before the upheaval.
2 ...... May 25, 1944
3 ...... January 10, 1945
4 ...... April 10, 1945
5 ...... December 2?, 1945

appeared at the top of the pile of sand imitating the roof mountain. If the end of the bar is flat, sand near the bottom is pushed up and it forms the central peak.

The volume of the pile of sand in this experiment must be exactly equal to that of the part of sand replaced by the pushed up bar. In actual case of volcano, the volume of the roof mountain must be equal to that of

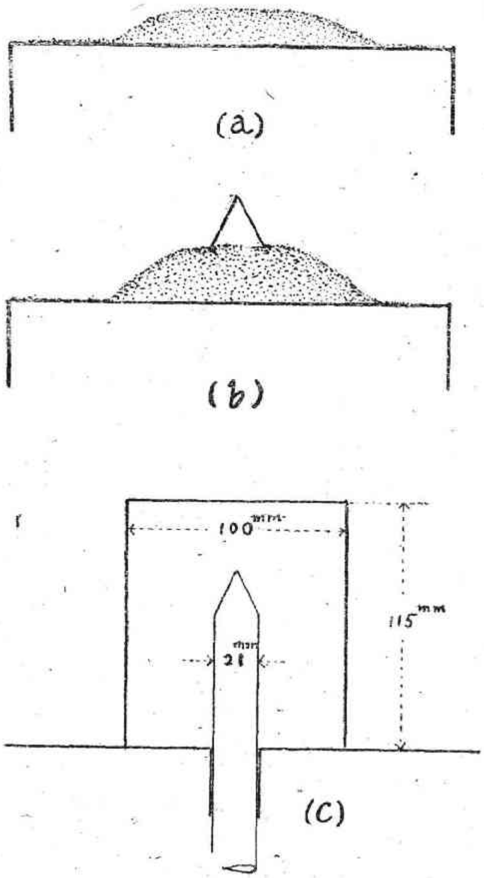

Fig. 4. Model experiment 1. Vertical movement of iron bar with conical end.
a) Formation of the roof mountain.
b) Formation of the central dome.
c) Sketch showing the position of the moving bar.

rocks replaced by the central magmatic mass, if the volcanic ash scattered over wider area is neglected. This neglection makes the estimation of the volume of the mountain too small. But if the loosening of rocks by volcanic action is taking in consideration, this neglection may not do serious effect on the estimation of the volume.

Using the Okamoto's map the writers estimated the total volume of the mountain. It is $1.07\times10^8 m^3$. If the area at different levels be assumed to be circular, their equivalent radii R are given by $R^2=\text{Area}/\pi$, which are shown in Fig. 5 by Curve A. The writers calculated the depth of the original level of the magmatic layer, from which the magmatic intrusion took place, assuming different forms of the intruded mass. The results are shown in Fig. 5.

It must be noticed that the new mountain, seen from north or south have an unsymmetric form as shown in Fig. 2. The peak of the dome is near the west end of the mountain. This can be imitated in the model experiment by pushing up the iron bar obliquely as shown in Fig. 6. But this cannot be a real model of the formation of the mountain. If the intrusion took place obliquely, the roof mountain must be first formed near the east end of the mountain, and the dome must appear near another end as shown in Fig. 6. But as it is clearly seen in Fig. 3, it was not the case. Mimatsu's sketches show

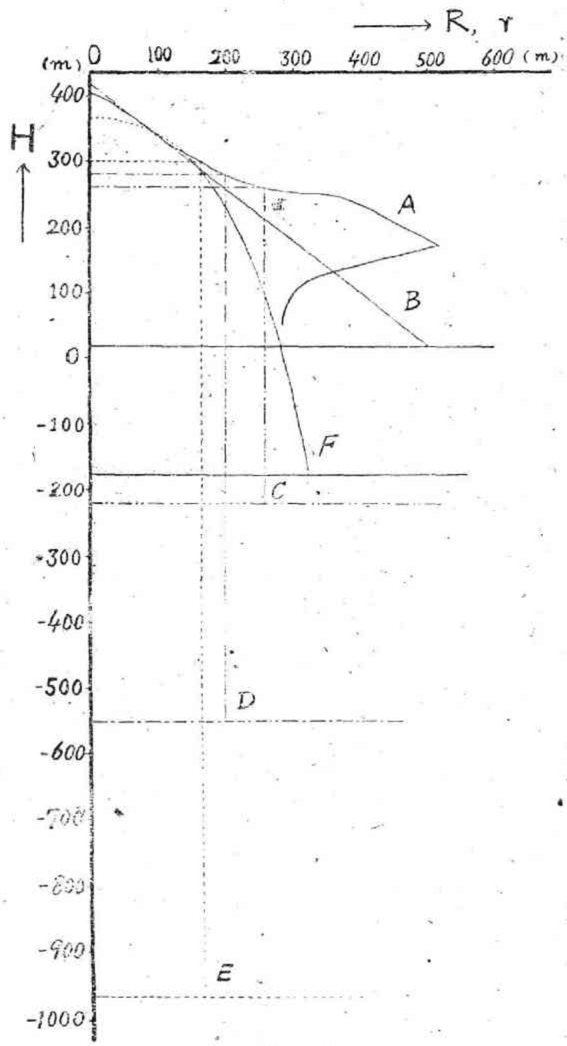

Fig. 5

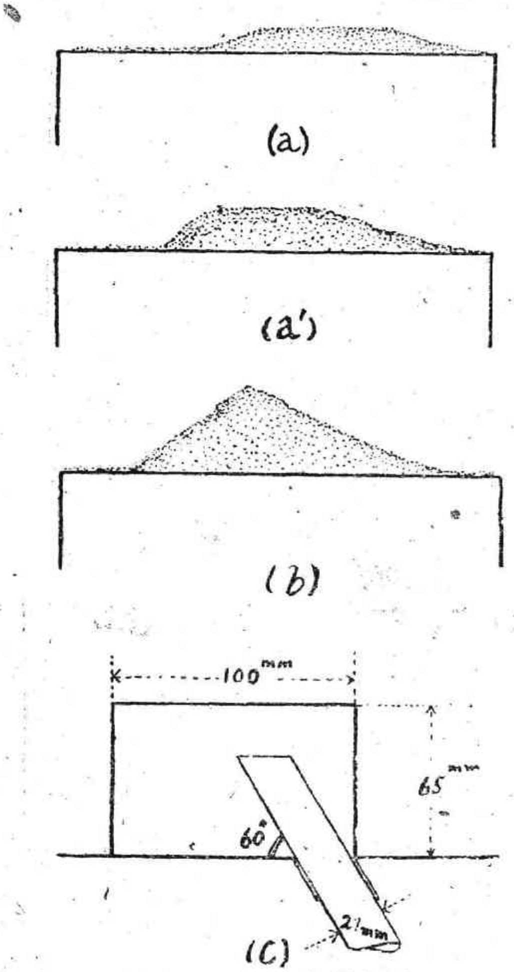

Fig. 6. Model experiment 2. Oblique movement of iron bar with flat end.
(a) First stage of the formation of the roof mountain.
(a′) Second stage of the formation of the roof mountain.
(b) Formation of the central dome.
(c) Sketch showing the position of the moving bar.

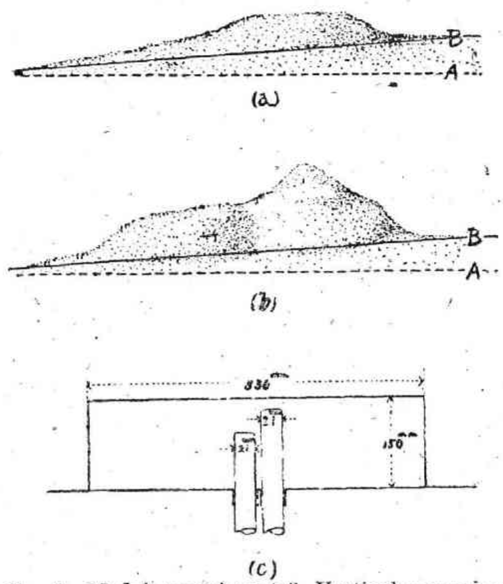

Fig. 7 Model experiment 3. Vertical movement of two iron bars with flat ends one after another.
(a) Formation of the roof mountain.
(b) Formation of the central dome.
(c) Sketch showing the position of the moving bars.
A......Horizon.
B......Original ground surface.

that the east part of the roof mountain was formed after April 1945 when the central dome appeared and considerably grew up. This can be approximately imitated by pushing up the bar on a side of a pile of sand previously made by the first experiment (see Fig. 7). It is very certain that the east part of the present roof mountain is thus a crypto-dome formed on the hill-side of the main mountain. This part of the roof mountain is estimated from Mimatsu's sketch to be about 20% of the total volume. In the calculation of the magmatic layer, the volume of the mountain must be reduced this amount. The depth given in Fig. 5 and Table I-III, which are not corrected, must be also a little reduced, for conical intrusion 10% and for cylindrical intrusion 20%. In Table IV the corrected values are given.

a) If the intruded mass is a cone as shown in Fig. 5. by curve B, the result of calucula-tion is as shown in Table I.

TABLE I

Height of roof mountain	270m	310m
Height of magmatic layer above sea level	+ 18m	+ 17m

b) If the intruded mass is a cylider of radius (r), then the height of the roof mountain (H) and the depth of the magmatic layer under the original ground surface (h) and its height from the sea level (M. L.) are as shown in Table II.

c) A more complicated form of the intruded column is assumed. It is something intermediate between the cylinder and the cone as shown in Fig. 5 by curve F. Its

TABLE II

H	r	h	M.L.	Notation of curves in Fig. 5
260m	256m	481m	− 221m	C
270	219	673	− 403	--
280	198	828	− 549	D
290	179	1028	− 738	—
300	162	1265	− 965	E
310	146	1595	−1285	—
320	123	2210	−1890	—

sectional area (S) at different levels (H) is given by

$$0.294\times10^{-8}\ S^2+7.05\times10^{-4}\ S=366-H,$$

where H is given in meters and S in square meters.

The height of magmatic layer above the sea level is as shown in Table III.

TABLE III.

Height of roof mountain	Height of magmatic layer
313.1m	−180m
266.1	−177

The assumption that the intruded mass has a conical form or the root of the magmatic column extends widely under the roof mountain, gives unreasonable results that the magmatic layer is above the sea level or a few meters under the village of Fukaba.

The simplest assumption that the intruded mass is cylindrical, gives reasonable results. The depth of the magmatic layer is depending upon the assumed radius. Which of the results is the case actually occurred is determined by comparing them to the model experiment.

The radius of the bar (r), the height of the roof mountain (h'), and the original depth of the upper end of the bar before it is pushed up in the model experiment have a certain relations. The relations are compared with the results of caluculation. It is shown in Table IV.

For the depth of the original magmatic layer of 400-750m under the sea level or 500-850m under the original ground surface, the calculation and the model experiment gives a good agreement.

One of the writers carried out the magnetic survey in this region in 1946 and 1947, and found a change of $\pm7'$ in the magnetic dip. This change in dip can be attributed to the magnetization of magmatic column by cool-

TABLE IV.

Depth of magmatic layer							
under sea level(m)		130	280	395	553	745	1010
under original ground surface(m)		230	380	495	653	845	1110
Radius of magmatic column (m)		256	219	198	179	162	146
h/r calculated		0.9	1.8	2.5	3.6	5.7	7.6
h/r observed							
$h'=150$m	a	—	—	2.1	4.2	6.4	—
	b	—	3.0	4.3	5.9	8.5	—
$h'=200$m	a	—	—	—	2.0	4.1	6.3
	b	—	1.7	2.9	4.3	5.8	8.3
R/r calculated							
$R=500$m		2.0	2.3	2.5	2.8	3.1	3.4
$R=650$m		2.5	3.0	3.3	3.6	—	—
R/r observed							
$h'=150$m	a	—	—	2.1	2.4	2.6	—
	b	—	2.5	2.6	2.8	2.9	—
$h'=200$m	a	—	—	—	2.0	2.4	2.9
	b	—	2.1	2.5	2.6	2.8	2.9

ing. The mean depth of such a disturbing magnetic mass is nealy 230m in rough estimation. If the magmatic column is uniformly cooled, its length must be 460m, and nearly agrees to the depth of the magmatic layer

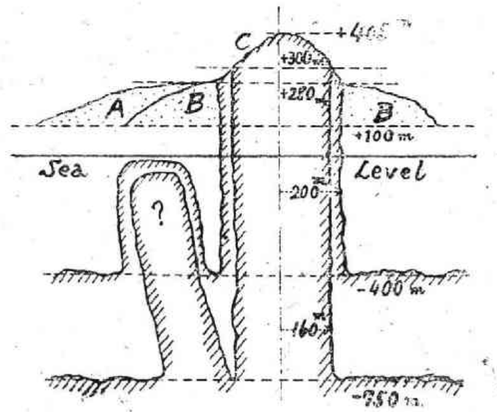

Fig. 8 Approximate section of the new mountain.

estimated here.

The writers thus concluded that the new mountain is so formed that nearly cylindrical magmatic mass intruded nearly vertically from a depth of 400-760m under the sea level into the west part of the mountain and formed a nearly circular roof mountain and that after the formation of the dome another intrusion took place in the east part of the mountain near the village of Fukaba and it formed a crpyto-dome, resulting the present prolonged form of the roof mountain in E-W direction. Fig. 8 shows the approximate section of the mountain.