13. *Recent Activities of Volcano Usu (VI). Precise Levelling Around Mt. Usu in 1949.*

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1. Introduction.

As reported in the previous papers,[1] the remarkable upheaval at the eastern base of Volcano Usu and extrusion of viscous lava on the former formation resulted in the birth of a new mountain higher than 200 m. From the morphological viewpoint, this new formation falls into three main parts; the first or the roof mountain, including a conical platform lacking its top part, measures about 250 m and 500 m in its upper and base diameters respectively and is 150–200 m higher than the area surrounding it. The second is composed of a conical lava dome 100 m high which is situated on the westward summit of the former formation. The third or the front mountain includes the hill of half-ring form which lies on the eastern margin of the roof mountain (Fig. 5).

On the basis of numerous levelling surveys and other kinds of measurements, the developments of those formations were brought to light, the results of which have been reported in this Bulletin.[2]

According to reports from American volcanologists,[3] about the same time of the recent outstanding eruption of Usu, or to be more exact, during the period covering several years from February 5, 1943, outflows of fresh lava resulted in the birth of a new volcano in the village of Paricutin in Micohacan, Mexico.

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1) T. MINAKAMI, *Bull. Earthq. Res. Inst.*, 25 (1947), 65, 71; 28 (1950).

2) *loc. cit.* 1)

3) J. GONZALEZ and W. F. FORSHAG, *Smithonian Rep.*, 3878 (1946), 223.
R. E. WILCOX, *Trans. Amc. Geophy. Union*, 28 (1947), 559, 567, 725, 29 (1948), 69, 355, 877.

Those two newly formed volcanoes are exactly same, i.e., they were both given birth to by extrusion of lava through newly opened craters on level cultivated land. But in respect of the mechanism of formation and structures they differ entirely. The new volcano at Paricutin is, as is usually the case, a stratified or strato volcano produced by the accumulation of volcanic ejecta, such as lava-flows, fragments of rocks and volcanic ash etc., while the newly formed mountain at Volcano Usu was found, as has been dealt with in the same Bulletin, by the upward movements of viscous lava towards the earth's surface, which heaved up the ground around the craters newly in action, forming a dome-shaped mountain there. Thus in the process of formation the two volcanoes present extremely different characteristics.

2. Precise Levelling along the Western and Southern Foot of Mt. Usu.

Although the investigations of the topographical deformations made during the recent eruption were examined by means of various methods, the surveys covered only the eastern region of this volcano and no available information was given with respect to the land deformations, if any, at the western and southern area of this mountain.

Judging from the fact that an upheaved mountain 200 m high was newly formed during the period 1944–1945, it will be quite natural to expect vertical movements of the land around the Usu volcano, though their amounts are unknown. From this viewpoint, the writers planned the redetermination of the heights of the first order bench marks on the route along the western foot of Usu and along the north-eastern coast of the Utiura Bay, that is, the southern base of the volcano. In the summer of 1949, precise levellings were carried out for the purpose, and to compare with the former survey in 1919, the bench mark No. 6604 located at the north-western corner of Lake

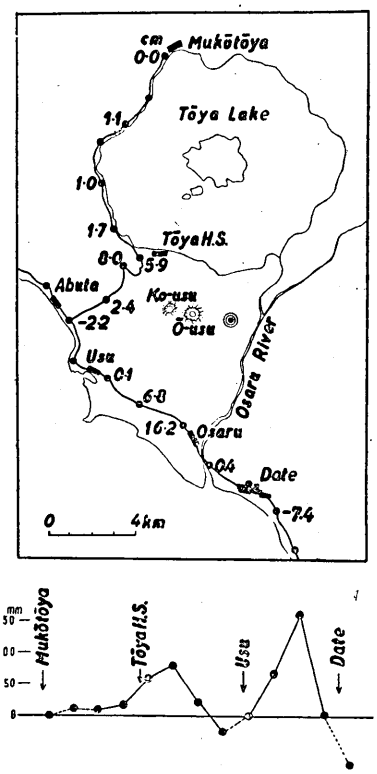

Fig. 1. Distribution of topographical deformation around Mt. Usu during 1919-1949.

Tōya (Dōya) was assumed as the fixed height during the period of those two surveys.

In Table I, are given the heights and their changes at the seventeen bench marks obtained by the former and present levellings. In order to investigate

Table I. Comparison of the results of precise levellings made in 1919 and 1949.
H_1; height of bench mark in 1919.
H_2; height of bench mark in 1949.
$\Delta H_1 = H_2 - H_1$; change in height.

B. M. No.	H_1	H_2	ΔH_1
	m	m	cm
6604	85.5009	85.5009 (fixed)	0.0
6603	86.2597	/	/
6602	86.8103	86.8217	1.1
6601	86.1558	/	/
6600	88.6848	88.6945	1.0
6599	86.3540	86.3709	1.7
6598	95.3932	95.4525	5.9
6597	150.5235	150.6039	8.0
6596	50.2057	50.2296	2.4
J. 4	3.9027	3.8804	−2.2
7193	9.7671	/	/
7194	3.9282	3.9288	0.1
7195	30.1495	30.2171	6.8
7196	6.5458	6.7081	16.2
7197	4.2710	4.2752	0.4
7198	5.5040	/	/
7199	14.0026	13.9284	−7.4

the general trend of rise and sink of these bench marks, their geographical distribution is indicated on the map of Fig. 1. In the table and the figure, we can find conspicuous rise at two groups of the bench marks, the first of which includes those at the western foot of Mt. Usu and the other at the southern skirt, being 8.0 cm for the former and 16.2 cm for the latter both in the maximum rise. Judging from the developments of the recent activity, it will be reasonable to infer that those remarkable upheavals at the two localities are extended towards the newly upheaved mountain at the eastern base of this volcano, though we have no information concerning the topographical deformations in the middle of the new formation and the bench marks.

In case of volcanic eruptions, it is rather an usual mode of land deformations that the area near the active craters rises and contrariwise the region more distant subsides. As will be seen in Fig. 1, the present land deformations are of the same mode as just mentioned. On the other hand, the remarkable rise at the southern and western roots of this mountain agrees well with the epicentral area of the earthquakes which occurred 2–5 km deep in the course of the recent activity, with which the preceeding papers[4] dealt.

On the basis of these facts mentioned above and taking into consideration the usual mode of land deformations made clear in many other volcanoes, we do not hesitate to conclude that the greater part of the topographical deformations elucidated by the present levelling should be directly connected with the recent catastrophic eruption of Usu.

To permit ready comparison between the mode of the land deformations undergone at the time of the 1910 activity with that of the recent eruption, changes[5] of height appeared during 1905–1912 and 1919–1949 are given on the diagram in Fig. 2, both times making use of the same bench marks.

From these tables and figures, it is worthy of note that notwithstanding the fact that the present bench marks used for the two series of levellings are situated at nearly equal distances from the two upheaved mountains formed in 1910 and in 1944–1945, their amounts of rise in the former activity were almost ten or several times those in the latest one.

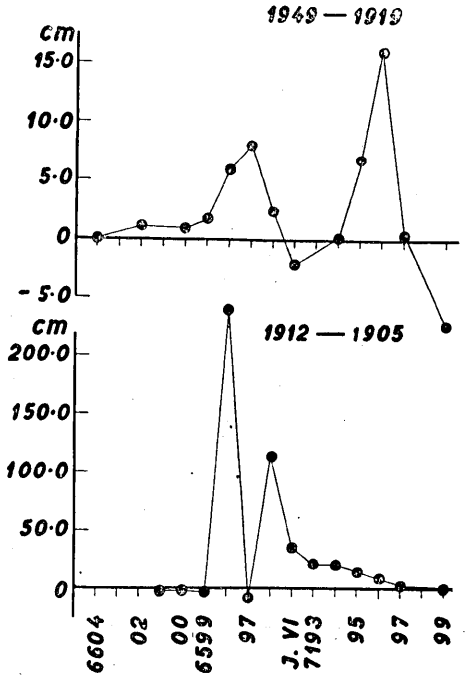

Fig. 2. Modes of upheaval and subsidence around Mt. Usu during 1919–1949, and 1905–1912.

In the 1910 activity, over 20 craterlets newly opened and were distributed over an area extending nearly 3 km from the northwestern foot of the volcano to the northeastern, while in the latest case, seven craterlets opened close to one another. However, so far as the upheaved mountains formed in

4) T. MINAKAMI, *Bull. Earthq. Res. Inst.*, 25 (1947), 71.
5) F. ŌMORI, *Bull. Imp. Earthq. Inv. Comm.*, 9 (1918-1921), 41.

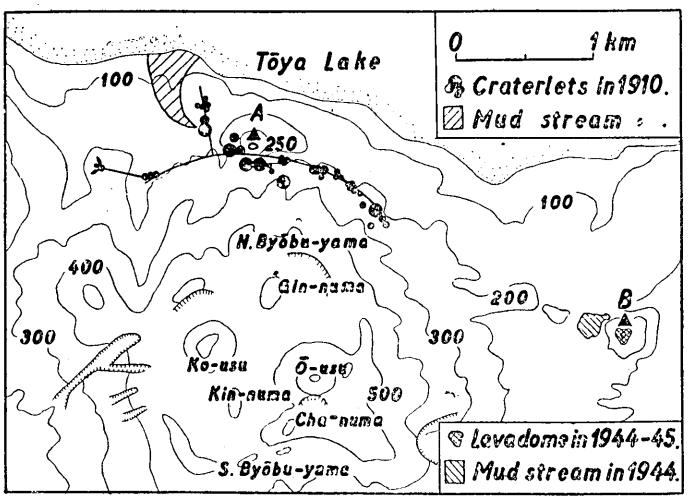

Fig. 3. Localities of the 1910 craterlets and the new mountains formed in 1910 and in 1944-1945.

A, the 1910 mountain.
B, the 1944–1945 mountain.

1910 and in 1944–1945 are concerned, they are quite similar in their height as well as in their volume. On the other hand, in the former case, no fresh lava extruded to the earth's surface, while in the recent eruption, fresh lava formed a lava dome partly covered by tuffaceous material on the upheaved mountain.

On the basis of comparisons of the volcanic phenomena just mentioned, it may be said that if the seismic activities followed were put out of question, the 1910 eruption was of greater scale, at least, in respect of the interior activity of the volcano which resulted in more remarkable land deformation in its affected area as well as in its amounts of rise than that in the latest case. At all events, it will be without doubt that the land deformations and the seismic activities accompanied with those eruptions were caused by intrusion or extrusion of the subterranean magma.

3. Precise Levellings on the New Mountain and at Its Northern Base.

As already mentioned, the recent activity of the Usu volcano came to an end towards October 1945, when the newly formed mountain with the lava dome on its summit had been completely built. In the case of the 1910 eruption, however, the mountain newly formed at the time together with the upheaved

land around the Usu volcano began to subside and decreased their upli ted amounts soon after the explosive activity.

In order to bring out clearly the subsequent land deformation of the 1945 mountain, series of bench marks were newly established in October 1948 on the route from the village Sōbetu to the base of the new mountain. At the

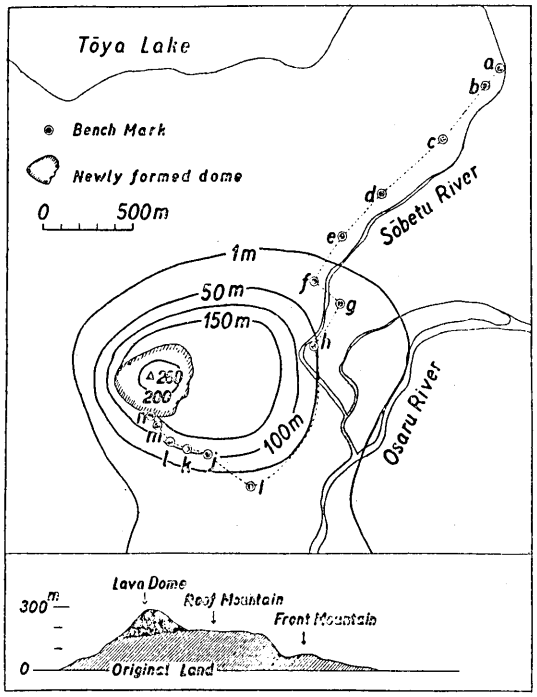

Fig. 4. Total amounts of upheaval of the new mountain, and locality of the bench marks newly established.

same time, precise levelling on this route was carried out and re-examined in July 1949 both by the writers. At the occassion of the latter survey, several bench marks were newly added on the flank and summit of the roof mountain, with a view to accurately determining their heights and their promising changes. As the result, at various positions on the roof mountain, the total amounts of rise caused in the course of the eruption were determined on the basis of comparison with the topographical map made prior to the recent activity.

Simultaneously, along the route running through the village Sōbetu to the base of the new mountain, 2 km south of the former, the two series of levelling surveys made clear the changes in heights of those bench marks, which took place during the nine months between the two times of levelling.

Table II. The results of the precise levellings on the route from the village Sōbetu to the base of the new lava dome.

H_5; height above sea-level before the eruption.
H_6; height examined in October 1948.
H_7, height examined in July 1949.
$\Delta H_2 = H_7 - H_5$; total rise caused by the recent eruption.
$\Delta H_3 = H_7 - H_6$; variations during from October 1948 to July 1949.

B. M. No.	H_5	H_7	H_6	ΔH_2	ΔH_3
		m	m		
		+55.21	+55.21		
	m	m	m	m	mm
(a)	55.21	0.0000	0.0000	0.0	0.0
(b)	55.44	0.2376	0.2386	0.0	−1.0
(c)	61.77	6.5644	6.5650	0.0	−0.6
(d)	55.15	−0.0436	−0.0441	0.0	0.5
(e)	54.10	−1.0785	−1.0777	0.0	0.2
(f)	53.50	−1.4088	−1.4051	0.3	−2.7
(g)	53.70	2.1952	2.1932	3.7	3.0
(h)	52.50	56.8996		59.6	
(i)	102.0	83.2906		36.5	
(j)	105.0	146.7626		97.0	
(k)	108.5	155.3727		102.1	
(l)	110.3	166.4349		111.3	
(m)	113.5	180.3811		122.1	
(n)	115.0	200.3921		140.6	

It must be, however, added that the total amounts of rise and their changes mentioned above both are determined by the following assumption; the bench mark No. (a) situated at the village Sobetu has been fixed in its height throughout the whole period in question. If we take into account the facts that the total uplift of the summit of the new formation amounts to more than 200 m and the subsequent variations in height may be dependent on the total amount of rise, such as in the case of 1910, the above assumption will not seriously affect the result, though the fixed bench mark is located near the new mountain, only 2.0 km distant.

The results of levellings are given in Table II together with the approximate heights above the sea-level of these bench marks prior to the recent activity. Positions of these bench marks and their total amounts of upheaval caused during 1943-1949, are illustrated on the map of Fig. 4.

As will be seen in the table, no marked change in height concerning these bench marks took place during the nine months after October 1948.

In conclusion, the writers wish to express their sincere thanks to Mr. K. Ikeda, director of Civil Engineering Section, Hokkaido Prefecture, for facilities and courtesy given them throughout the levelling surveys including the 1944-1949 surveys.

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13. 最近の有珠山の活動 (其の6)
有珠山周邊の精密水準測量

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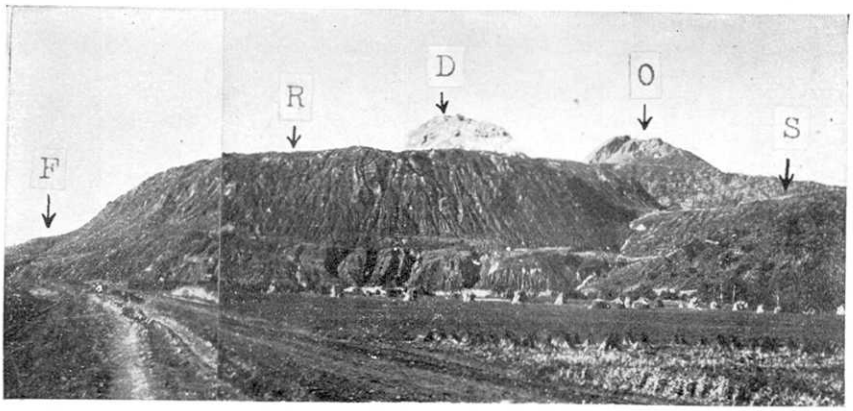
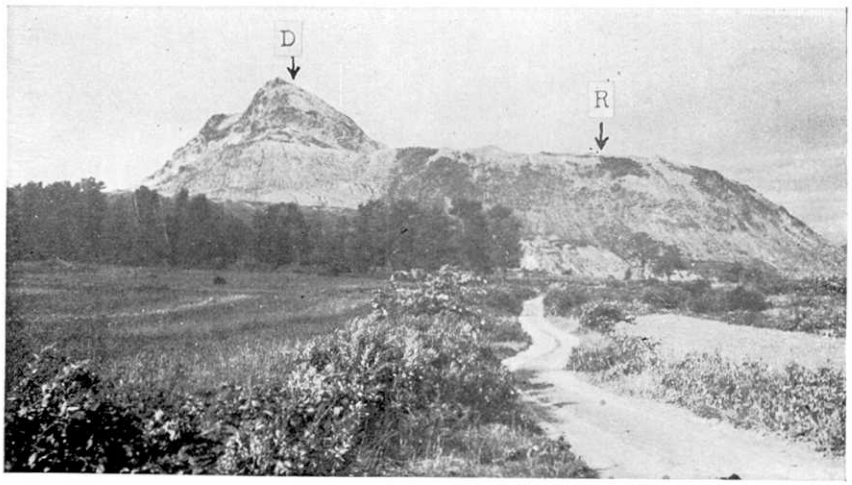
今迄に報告した最近の有珠山の活動に伴つた地形變動は專ら同火山の東麓地域の隆起現象即ち新山の成長の經過に關するものであつた．本文は火山の西北，西及び南の山麓を通る既設の一等水準點を改測し，今回の著しい噴火に伴つたやゝ廣い地域に亘る水準變化の模様を明かにせんと試みたものである．前回1919年の測量結果との比較から變動を求めたので，この30年間に亘つて生じた水準變化をその中に含むものであるが今回の測量で明かにされた隆起，沈下の分布から判斷して，その大部分は今回の噴火に伴つたものと推定される．それにしても最も著しい變動は同火山の南側（有珠部落附近）の僅か16糎の隆起を示すに過ぎなかつた．一方その北方約6粁に200米に及ぶ隆起によつて新山が形成された事を考えると，著しい變動は極めて限られた地域である事が判る．また，火山の南側及び西側の山麓の隆起地域は前に報告したA型地震（震源の深さ2-5粁）の震央域と一致している．

1948年10月新山の東北2粁の位置にある潮の町部落より新山中度に至る區間に約10個の水準點を新しく設け，第1回の精密水準測量を行つた．その後1950年7月に改測した結果によるとこの9ケ月に殆んど水準變化を示さなかつた．



(a)



(b)

Fig. 5. The new mountain (Syowa-sinzan or Showa-shinzan) viewed from north (a) and south (b).
D, Lava dome. R, Roof mountain. F, Front mountain.
O, Ō-usu (old lava dome, summit of Usu). S, Somma of Usu.