

The Usu-san Eruption and the Earthquake and Elevation
Phenomena. II. [Comparison of the Bench Mark
Heights in the Base District before and
after the Eruption.]

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With Plates XXX—XXXI.

1. Introduction. As described in No. 1 of this volume, the volcanic outbursts in 1910 of the Usu-san were followed by the formation of the "New Mountain." The elevation phenomena were, however, evidently not confined to the latter alone; as, for instance, was observed in November of the above mentioned year in the vicinity of the town of Abuta at the SW base of the volcano, where the ground indicated marked signs of the local changes in height, such that the fence forming the boundary of a portion of the cultivated field, formerly level, became at the time in question invisible from one side to the other. At the request of the present author, the Military Survey Department undertook the re-determination of the heights of the 1st order bench marks on the lines of precise-levelling running along the NE coast of the Volcano Bay and along the western foot of the Usu-san. In the following §§ is given a discussion of the height variation deduced from these measurements, carried on in 1911 and 1912.

2. Results of precise levelling. In the summer of 1911, the height was examined along the Volcano Bay coast from the

vicinity of the town of Benbe SE'ward to a place called Abuta-Tokotan, midway between the towns of Abuta and Usu, then along the SW'tern base of the Usu-san to the vilage of Tokotan on the Toya Lake, thence to Muko-Toya along the W'tern coast of the latter, the total distance being about 25 km. In the Summer of 1912, the measurement was repeated along the above mentioned rout, being, further, extended SE'wards for a distance of about 12 km along the coast of the Bay down to the vicinity of the town of Nishi-Monbets, which is situated about 8 km to the SE of the central crater of the Usu-san. The results are shown in the following Table, the heights before the eruption being those determined in 1905.

TABLE I. HEIGHTS OF THE 1ST ORDER BENCH MARKS IN THE NEIGHBOURHOOD OF THE USU-SAN BEFORE AND AFTER THE ERUPTION OF 1910.

(Districts of the Abuta and Daté Villages, Province of Iburi, Hokkaido.)

Locality.	No. of Bench Mark.	Height <i>before</i> the Eruption.	Height <i>after</i> the Eruption.	
			in 1911.	in 1912.
Abuta Village District.				
Chasnai.	7190	104.6111 ^m	104.6111 ^m	—
Kriya.	7191	60.2509	60.2459	60.2509
Frenai.	7192	2.6572	2.6334	2.6365
Abuta-Tokotan.	VI	3.5676	3.9278	3.9234
Biwaok.	6596	49.0857	50.2550	50.2366
Tokotan.	6597	150.6192	150.5599	150.5307
Do.	6598	93.0124	95.4505	95.4231
Puoshima.	6599	86.3755	86.3526	86.3550
Poromoi.	6600	88.6877	88.6842	88.6862
Do.	6601	86.1620	86.1603	86.1620
Oozak.	6026	86.8139	86.8107	—
Mukō-Toya.	6603	86.2596	86.2596	—
Omonai.	7193	9.5764	—	9.7831

Locality.	No. of Bench Mark.	Height <i>before</i> the Eruption.	Height <i>after</i> the Eruption.	
			in 1911.	in 1912.
Daté Village District.				
Sneushima, (Usu).	7194	^m 3.7524	—	^m 3.9525
Do.	7195	30.0242	—	30.1637
Osaru-bets.	7196	6.4822	—	6.5588
Tarayama, (Nishi-Monbets).	7197	4.2696	—	4.2809
Urahama, (,,).	7198	5.4096	—	5.5162
Shashikese (Higashi-Monbets).	7199	14.0073	—	14.0073

3. Change in height before and after the eruption. In Table II is given a comparison of the heights at the different localities before the eruption with those found in 1911 or 1912, or with the means for the two years. As may be expected from the proximity to the site of the New Mountain, the bench mark No. 6598 at Tokotan indicated the maximum elevation of ^m2.4244; while the bench mark No. 6596, situated nearly midway between the Toya Lake and the Volcano Bay, was elevated to the amount of ^m1.1601. At Abuta-Tokotan on the coast of the latter, the elevation was still considerable and equal to ^m0.358, although the distance from the New Mountain is 6 km. On the other hand, the bench mark No. 6597, situated not far from No. 6598, suffered a depression of ^m0.0739; while the two others Nos. 7192 and 6599, at the distance of about 2 km to the NW of Abuta-Tokotan and Tokotan respectively, were each depressed by about ^m0.022. The amounts of the elevation or depression at the different places are also marked on the maps Figs. 1 and 2.

TABLE II. CHANGE IN HEIGHTS OF THE BENCH MARKS
BEFORE AND AFTER THE ERUPTION.

No. of Bench Mark.	Height before the Eruption = I.	Height after the Eruption = II.	Height Difference. II - I.
			(Increase.)
6598	^m 93.0124	^m 95.4368	+2.4244
6596	49.0857	50.2458	+1.1601
VI	3.5676	3.9256	+0.3580
7193	9.5764	9.7831	+0.2067
7194	3.7524	3.9525	+0.2001
7196	30.0242	30.1637	+0.1395
7196	6.4822	6.5588	+0.0766
7197	4.2696	4.2809	+0.0113
7198	5.4096	5.5162 ^(newly set.)	—
7199	14.0073	14.0073	+0.0000
			(Decrease.)
7190	104.6111	104.6111	-0.0000
7191	60.2509	60.2484	-0.0025
7192	2.6572	2.6350	-0.0222
6597	150.6192	150.5453	-0.0739
6599	86.3755	86.3538	-0.0217
6600	88.6877	88.6852	-0.0025
6601	86.1620	86.1612	-0.0008
6602	86.8139	86.8107	-0.0302
6603	86.2596	86.2596	-0.0000

From Table II and Fig. 1, it will be seen that marked elevation took place at all the bench marks between Tokotan and Abuta-Tokotan (with the exception of No. 6597), and those along the coast of the Volcano Bay between the latter place and the town of Nishi-Monbets. As, further, the SE corner of the lake coast in front of the West-Kohan School indicated an upheaval of

some $1\frac{1}{3}$ metres, it may be assumed that the whole mountain mass of the Usu-san and its base suffered an elevation, doubtless extended some distance to beneath the Toya Lake. It is hereby to be noted that the submergence of a portion of the lake coast at the N. foot of the New Mountain is a purely local effect, being the necessary consequence of the steep upheaval of the slope ground.

The curves A and B in the map, which have been drawn by interpolations and exterpulations between the different stations, indicate respectively the line of no level change and the line of 1 metre elevation. The region lying to the NW of the boundary line A suffered a slight but distinct depression, which probably took place also in the outside and submarine tract to the SW. The depression was evidently the secondary consequence of the much greater elevation of the neighbouring region, which formed the primary phenomenon in the volcanic disturbance in question. It is worthy of note that the SW and S. portions of the line A run nearly parallel to, and not much distant from, the coast line of the Volcano Bay, a fact, which seems to indicate that the land tract, on which the Usu-san stands, forms a system of rising region.

4. Change in height between 1911 and 1912. A comparison of the heights of the different bench marks determined in 1911 with those again determined in 1912 shows that a sort of level readjustment was going on both in the upheaved and the depressed regions to no small degree. In the following table is given the height difference between the two years 1912 and 1911, being *minus* when decreasing, and *plus* when increasing.

TABLE III. CHANGE IN HEIGHT OF THE BENCH MARKS
BETWEEN 1911 AND 1912.

No. of Bench Mark.	Height in 1911.	Height in 1912.	Height Difference, (1912)-(1911).
VI	m 3.9278	m 3.9234	(Decrease.) - 4.4mm.
6596	50.2550	50.2366	-18.4
6597	150.5599	150.5307	-29.2
6598	95.4505	95.4231	-27.4
7192	2.6334	2.6365	(Increase.) + 3.1mm.
6599	86.3526	86.3550	+ 2.4
6600	88.6842	88.6862	+ 2.0

From the above table, it is seen that the three bench marks Nos. 6596, 6598, and 6597, the first two of which had been elevated by the greatest amount of 1.16 to 2.4244 m, now indicated the depressions of 18.4 to 29.2 mm. On the contrary, the three others, Nos. 7192, 6599, and 6600, which had been depressed by the maximum amount of about 22 mm, were now raised by 2.0 to 3.1 mm. The ratios of the downward and the upward restitutions were thus some 1/70 to 1/89, and 1/8 respectively, the latter being much greater than the former.

In the map (Fig. 2), the line of no level variation has been drawn by interpolation between the different stations. The sinking and the rising tracts are now respectively on the E. and on the W. sides of the boundary line, being reverse to what took place in the main change which immediately followed the eruption. These facts suggest naturally the case of an unstable mass or a portion of the earth's crust floating, as it were, on the surface of the magma, and leads to the question of the tilting of the volcanic mountain. It is likely that the process of the level fluctuation continues for

many a year to come, at least so long as the volcano is in a more or less active condition.

5. Conclusion. The problem of level change in volcanic districts forms an exceedingly interesting branch of geophysical research. Seismologically it is extremely desirable to investigate the changes in level, which may take place in districts belonging to active earthquake zones previous to the occurrence of destructive disturbances.

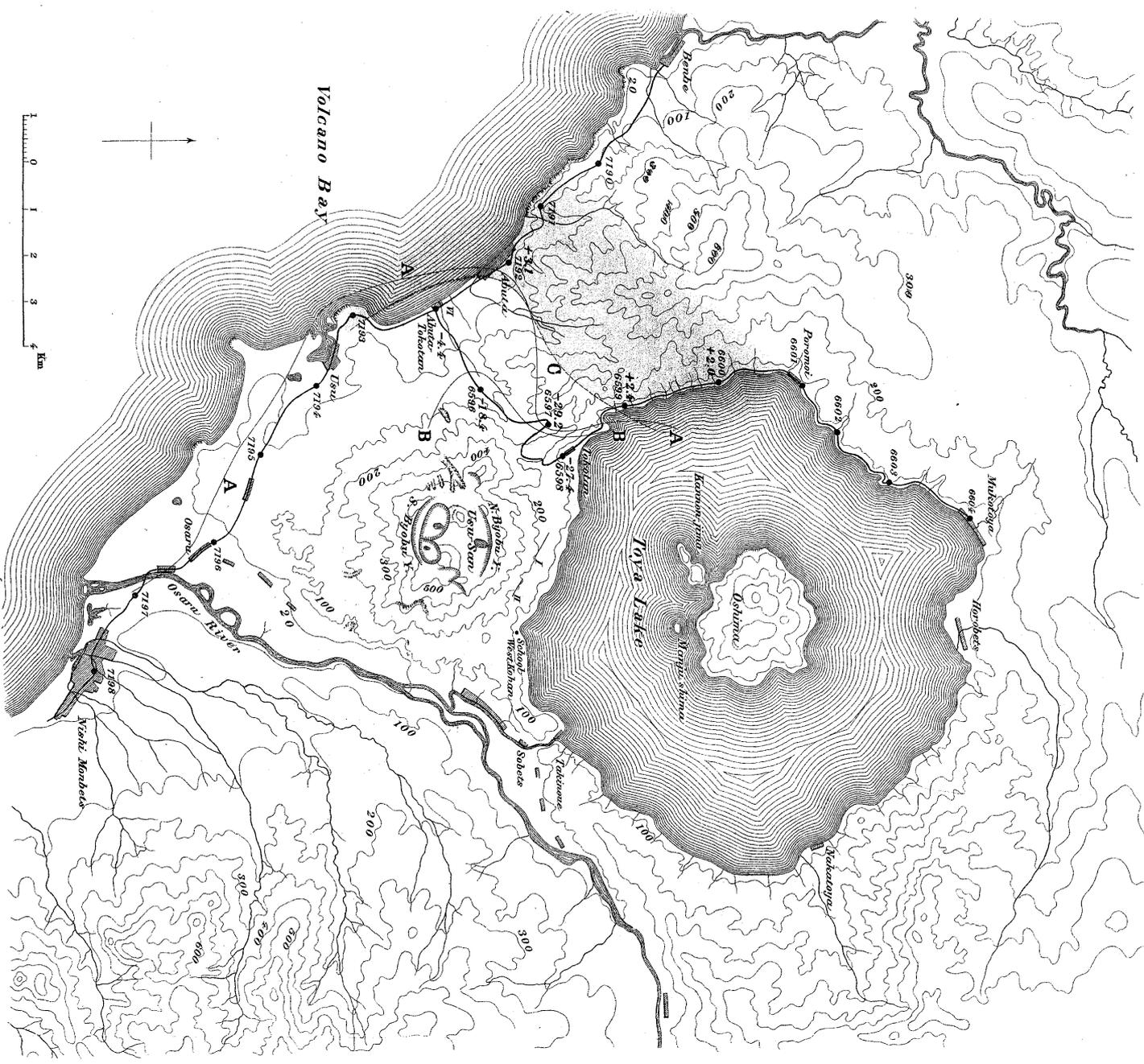


Fig. 2. Map showing the change in Height in the Usu-san District between 1911 and 1912.

Red figure indicates the amount of the increase, and blue figure the amount of the decrease, of the bench mark height in 1913 relative to that in 1911, in mm.

I, II are the Dislocation Lines of the "New-Mountain".

Contour lines, which relate to the topography before the eruption, are given for heights of 20 m, 100 m, 200 m, 300 m, etc. above sea-level.

-  Town or village.
-  Line of precise levelling and bench marks.
-  Elevated Region.
-  Depressed Region.

