17. *Land Deformation of the Muroto Point before and after the Nankaido Great Earthquake on Dec. 21, 1946.*

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(I) The remarkably regular change in height of the Muroto Point of South-Eastern Shikoku and of the Shio-no-misaki point of Kii Peninsula before 1942 was noted with special attention by some investigators[1]; that is to say, both points had been sinking with almost constant rate, about 7 *mm/year* at the Muroto point and about 4 *mm/year* at the Shiono-misaki, at least during the period after 1895 when the first precise levelling surveys in their neighbourhood were carried out.

On the contrary, both points abruptly upheaved accompanying the Great Earthquake in the South-Western Japan on Dec. 21, 1946, the magnitude of upheaval at the Muroto and Shio-no-misaki amounting to about 95 *cm* and 60 *cm* respectively. The re-survey of precise levelling in the areas covering Shikoku and Kii Peninsula has begun just after the occurrence of the earthquake by Geographical Suruey Bureau of Japan, the results of this survey obtained until the present showing a striking regularity of the behaviour of land deformation accompanying the Great Earthquake.

The writers, on the other hand, repeated four times the precise levelling survey in the neighbourhood of the Muroto Point for the purpose of studying the progress of tilt in the said place after the Great Earthquake.

(II) The levelling route about 14 *km* long, from Bench Mark No. 5137 to No. 5144 in Fig. 1 in the neighourhood of Muroto Point was surveyed during Jan. 6–14 in 1947, about 20 days after the Great Earthquake, and again during Mar. 4–6 in the same year, while the route from No. 5136 to No. 5147, which is about 22 *km* in length and includes the above-mentioned route, was surveyed during Jan. 30-Feb. 4 and again during July 5–9 in the same year. Thus, the route from

1) A. IMAMURA, *Zisin (Earthquake)*, **6** (1934), **9** (1937), 200.

No. 5137 to No. 5144 was surveyed four time after the earthquake. The instrument and method of each levelling survey followed the regulations for the first order levelling survey defined by Geographical Survey Bureau of Japan; that is, the closing error for the route $s\,km$ long should be less than $1.5\times\sqrt{s}\,mm$.

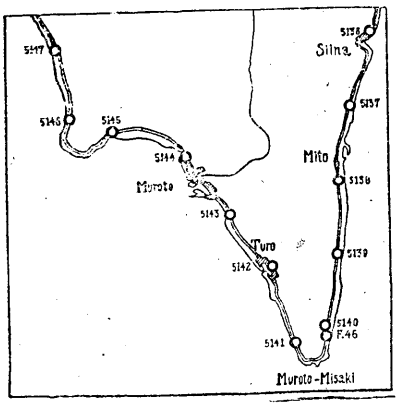

Fig. 1. Levelling route in the neighbourhood of Muroto Point. (1/200,000)

This levelling route was first surveyed in 1895, and again in 1929, and further the route along west coast of the peninsula alone was surveyed in 1935. For the purpose of showing the tilting motion in the neighbourhood of Muroto point, the results of those all surveys are given in Tables I and II and in Figs. 2 and 3, where Bench Marks No. 5137 and No. 5136 are respectively taken as the base-points, to which change in height of the other bench marks are referred.

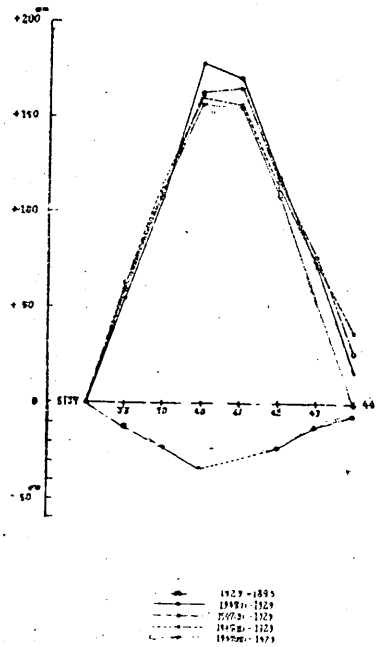

Fig. 2. Change in height of bench marks.

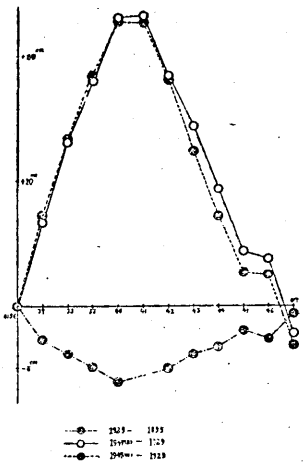

Fig. 3. Change in height of hench marks.

(III) The results given in Tables I and II being compared with the distribution of bench marks shown in Fig. 1, it will be seen that, generally speaking, the land in the neighbourhood of the Muroto point had continued to incline southward before the earthquake, while it abruptly inclined northward at the time of occurrence of the earthquake. The precise direction of tilting motion during 1895–1929 and that during 1929–1947, (practically almost all parts of the latter movement being a sudden tilt accompanying the earthquake), was determined by Miyabe's method[2], the result showing that the former tilt was in the direction of N10°W, while the latter was in the direction of S10°E, just opposite

Table I.

B.M.	1929—1895	1935—1895	1947 Jan. —1929	1947 Feb. —1929	1947 Mar. —1929	1947 July —1929
	mm		mm	mm	mm	mm
5137	0.0	——	0.0	0.0	0.0	0.0
5138	—11.9	——	+ 54.7	+ 63.9	+ 63.7	+ 60.9
5139	—22.5	——	+108.6	+112.5	+113.7	+111.9
	mm					
5140	—34.1	0.0	+178.5	+163.5	+160.6	+157.0
5141	——	——	+171.0	+165.6	+156.8	+156.7
5142	—23.5	——	+118.8	+117.0	+113.0	+108.9
5143	—11.9	——	+ 71.9	+ 76.2	+ 74.3	+ 52.6
5144	— 6.4	+27.7	+ 16.2	+ 26.0	+ 37.0	— 0.3

Table II.

B.M.	1929 1895	1935—1895	1947 Feb. —1929	1947 July —1929	1947 July—Feb.
	mm	mm	mm	mm	mm
5136	0.0		0.0	0.0	0.0
5137	—26.6		+ 67.8	+ 72.2	+ 4.4
5138	—38.5		+131.7	+133.1	+ 1.4
5139	—49.1		+180.3	+184.1	+ 3.8
5140	—60.7	0.0	+231.3	+229.2	— 2.1
5141	——	——	+233.4	+228.9	— 4.5
5142	—50.1	——	+184.8	+181.1	— 3.7
5143	—38.5	——	+144.0	+124.8	—19.2
5144	—33.0	+27.7	+ 93.8	+ 71.9	—21.9
5145	—19.9	+43.9	+ 43.5	+ 26.6	—16.9
5146	—26.1	+40.4	+ 37.5	+ 24.9	—12.6
5147	— 6.3	——	— 21.6	— 31.0	— 9.4

2) N. MIYABE, *Bull. Earthq. Res. Inst.*, **9** (1931), 256.

to the former case. Hence, the change in height of each bench mark along the route from No. 5137 to No. 5144 during 1895–1929; 1929–Jan., 1947; Jan., 1947–Feb., 1947; Feb., 1947–Mar., 1947; and Mar., 1947–July, 1947 are projected on a plane of N10°W-S10°E in direction, the results being shown in Fig. 4. As will be seen in this figure, the land around Muroto point is, generally speaking, again inclining southward after the earthquake, though it seems that undulations of short wave length superpose on the said general inclination, and further that the land is inclining also in westward direction especially during the period of March, 1947–July, 1947.

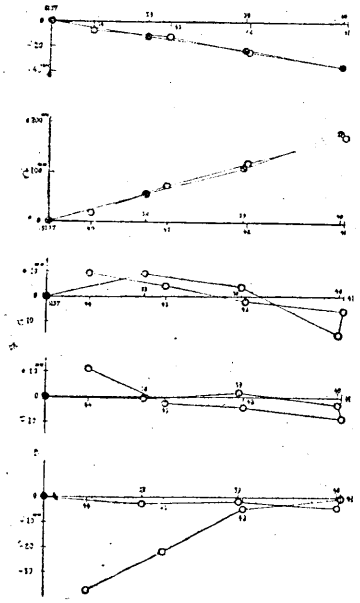

Fig. 4. Change in height of bench marks No. 5137~No. 5144, projected on a vertical plane in direction of N 10°W-S 10°E.

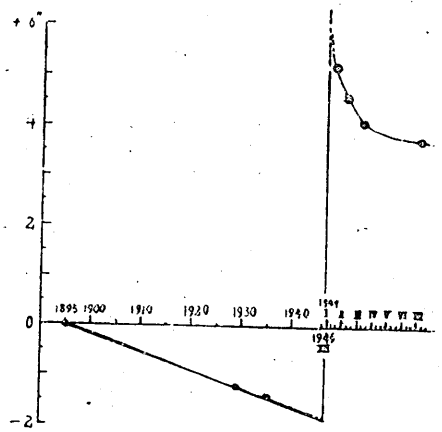

Fig. 5.

In Table III and in Fig. 5, the amount of tilt in the direction of N10°E at each epoch is summarized, where the corresponding value at 1935 was derived with reduction from the observed values along the west-side sea coast alone. It will be concluded here that the neighbourhood of the Muroto point had been inclining toward S10°E direction with nearly constant velocity of 0.0001″/day until, at least, 1935 and probably until the time little before the occnrrence of the great earthquake, and the abrupt tilting motion toward the reverse direction ac-

companying the earthquake exceeds 7″; while the land is now rather rapidly tilting again toward the direction of S10°E, the velocity of

Table III.

Date	Tilt in the direction of N 10° W-S 10° E	Change in Tilt	Mean Velocity
1895	0 (Assumption)		
1929	−1.2″	−1.2″	-1.0×10^{-4}″/day
1935	−1.4″	−0.2″	-0.9×10^{-4}
1947, I	+5.2″	+6.6″	——
1947, II	+4.6″	−0.6″	-3×10^{-2}
1947, III	+4.1″	−0.5″	-1.7×10^{-2}
1947, VII	+3.8″	−0.3″	-2×10^{-3}

tilting motion is gradually decreasing with time, though it is much larger than that before the earthquake.

(VI) It must be mentioned that the mode of deformation of the land after the earthquake has been much complex compared with those before and accompanying the earthquake. This fact may be interpreted as that the upper parts of the earth's crust, which were much disturbed by the occurrence of earthquake, are recovering their new equilibrium individually, probably in the manner of movement of crustal blocks.

As to the westward tilt during March to July, 1947, the result of repeated surveys from No. 5136 to No. 5147, which is shown in Fig. 3, will give a clear picture. This result shows that west-side sea coast from No. 5142 to No. 5147 subsided remarkably during a few months before July, 1947. For the purpose of detecting the areal distribution of such land deformation as mentioned above, a new levelling route connecting Bench Marks No. 5137 and No. 5144 was set and surveyed in December, 1947. The triangular levelling route of No. 5137-No. 5140-No.5144-No.5137 will hereafter be surveyed intermittently, much more clear picture of the land deformation in the neighbourhood of the Muroto being expected from the results of this triangular-route surveys.

The most important problem here will be the dynamical cause of the said tilt, especially relating to the great earthquake and its after shocks. This point will be examined in future by careful and continuous surveys and studies.

In conclusion, the writers wish to express their sincere thanks to Ministry of Education for the grant received and to Mr. Y. Harada of Geographical Survey Bureau for his valuable help in the course of our surveys.