

TOPOGRAPHICAL CHANGES ACCOMPANYING EARTHQUAKES OR VOLCANIC ERUPTIONS.

By

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Introduction.

Tiltings of the earth, which may be regarded as precursors of earthquakes, seem to take place in stages or steps; a very recent example being the great Kwantō earthquake of 1923. This earthquake was preceded by tilting in its earliest stage as attested at Misaki by the slow coastal subsidence which had been going on for a few decades until the year 1920, when the movement entered the intermediate stage, and which, after continuing for two more years, was found to have resulted in an uplift of as much as 6 cm. The remarkable upheaval that preceded the Sekihara earthquake of Oct. 27, 1927, was caused by tilting of either the earliest, or the intermediate stage; in all probability the latter. On the other hand, the conspicuous upheavals that preceded the great Adigawara earthquake of Feb. 28, 1793, and of Tango of Mar. 7, 1927, were undoubtedly owing to tiltings in their last stages.

Recent experiments by Prof. Ishimoto with his new clinograph have thrown considerable light on the foregoing phenomena. The results of his investigations seem to agree in indicating that the pre-seismic earth-tiltings in their last stages occur with every moderate shock, though he has not yet experimented with the severe or very violent ones. It is worth noting at the same time that the Sekihara earthquake of Oct. 27, 1927, revealed the exist-

ence of a close connexion between such pre-seismic tiltings and the acute tiltings that accompany actual earthquakes. Such a connexion was observed also in the case of the great Kwanto earthquake of 1923, although in a vague and ill-defined way.

From these evidences it may be regarded as established that the character of the acute earth-tiltings which accompany an earthquake is inferable from the chronic tiltings that precede the earthquake, and vice versa.

It will thus be seen that the study of pre-seismic earth-tiltings, together with that of the acute earth-tiltings, besides being of great interest scientifically, are essential to the investigation of earthquake prediction.

While the chronic earth-tiltings going on in some regions are closely related to earthquakes, it is not always possible to establish a similar relationship for those going on in other regions. All those in Japan, as far as we know, come under the first category, but cases can be cited from other regions which do not appear to be connected in any way with earthquakes. Thus in certain parts of the Baltic coast of Scandinavia the land has been rising uniformly at a yearly rate of about one cm. at the maximum.

Another phenomenon experienced in this country is that changes of land-level take place antecedent to, simultaneously with, or after, volcanic eruptions. The eruptions of Sakurazima and Ususan are good recent examples. Since it has been satisfactorily proved that topographical changes which take place prior to volcanic eruptions have characteristics in common with those that take place prior to earthquakes, the study of the former has assumed an importance in no way inferior to that of the latter.

In consideration of the foregoing it may truly be claimed

that the investigation of topographical changes accompanying earthquakes or volcanic eruptions, whether they take place before, simultaneously with, or after them, takes rank as one of the most important problems of practical seismology. This was fully recognised by the Imperial Earthquake Investigation Committee who spared no pains to avail of every possible opportunity for the collection of data concerning these phenomena. The data covers a dozen earthquakes and two volcanic eruptions, some of which have already been made public by the late Prof. Omori together with a few by the present writer. There are a few earthquakes, however, the data for which have not yet received the full attention of investigators, and the present paper contains, amongst others, the results of studies of such new data, together with brief reviews of what have already been published. It is also hoped that the paper will afford access to the literature of the subject for those desirous of making extended studies of the phenomena. The contents of the paper are

Chapter I. General view of a cycle of earth-tiltings.

Chapter II. Topographical changes in the past that were accompanied by earthquakes.

- No. 1. The Tosa earthquake of 684.
- No. 2. The Senrigahama earthquake of 1331.
- No. 3. The Bungo earthquake of 1596.
- No. 4. The Kwanto earthquake of 1703.
- No. 5. The Nankaido earthquake of 1707.
- No. 6.* The Adigasawa earthquake of 1793.
- No. 7.* The Sado earthquake of 1802.
- No. 8. The Kusakata earthquake of 1804.
- No. 9. The Zenkôzi earthquake of 1847.
- No. 10. The Iga-Ise earthquake of 1854.

No. 11. The Nankaido earthquake of 1854.

No. 12.* The Hamada earthquake of 1872.

No. 13. The Riku-U earthquake of 1896.

No. 14. The Formosa earthquake of 1906.

Chapter III. Recent topographical changes that were accompanied by earthquakes, and which were investigated by means of precise levellings.

No. 15. The Mino-Owari earthquake of 1891.

No. 16. The Tokyo earthquake of 1894.

No. 17. The Susaka earthquake of 1897.

No. 18.* The Anegawa earthquake of 1909.

No. 19. The Horisya earthquake of 1917.

No. 20. The Oomati earthquake of 1918.

No. 21. The Miyosi earthquake of 1919.

No. 22. The Simabara earthquake of 1922.

No. 23.* The Kwantō earthquake of 1923.

No. 24. The Tazima earthquake of 1925.

No. 25.* The Tango earthquake of 1927.

No. 26.* The Sekihara earthquake of 1927.

Chapter IV. Topographical changes that have accompanied volcanic eruptions.

No. 1. The Usu eruption of 1910.

No. 2. The Sakurazima eruption of 1914.

Chapter V. Concluding remarks.

Chapter 1. General View of a Cycle of Earth-Tiltings.

Undoubtedly in remote geological times upheavals and subsidences of land, or more generally speaking, earth-tiltings, took place on a much grander scale than in recent times. The exact

* Earthquake accompanied by pre-seismic topographical change.