CHAPTER X. NON-ERUPTIVE VOLCANIC EARTHQUAKES OBSERVED AT YUNO-TAIRA, ASHINO-TAIRA, AND THE ASAMA PASTURE GROUND.

102. I describe below, just by way of examples, only a few typical cases of the Asama-yama volcanic earthquakes which were accompanied by no eruption; the illustrative diagrams being given in Figs. 70 and 71.

103. ***Examples of shocks of short duration observed at Yuno-taira.*** In this § I describe a few cases of the volcanic shocks, whose principal portion was of a very short duration.

Earthquake of Sept. 13th, 1911; at 8. 43. 09 p.m.: Longitudinal Component. (Fig. 71.) (Duration=10 sec.) The commencement of the earthquake was perfectly abrupt, the 1st displacement being 0.055 mm directed toward the crater, followed by the maximum movement of $2a=0.12$ mm directed away from it. Thereafter the motion rapidly decreased, the duration of the earthquake proper being only 2.6 sec. The end portion, about 7 sec. in duration, consisted of minute movements, whose 2a was less than 0.001 mm. This earthquake was preceded by a very small shock, which occurred at 8. 42. 30 p.m., and whose initial and maximum displacement was about 0.001 mm.

Earthquake of Sept. 26th, 1911, at 3. 24. 46 and 3. 24. 56 a.m.: Longitudinal Component. These two shocks together formed a continuous disturbance, whose principal portion lasted 5.1 sec., the max. 2a's being respectively 0.012 and 0.011 mm. The end portion was very small and lasted about 5 sec. The 1st earthquake was preceded 9 sec. earlier by a very slight shock of total duration=3 sec.

Earthquakes of Sept. 26th, 1911, at 3. 26. 16 and 3. 26. 37

a.m.: *Longitudinal Component.* The 1st earthquake, which was not sensible and lasted 21 sec., began with an initial displacement of 0.002 mm. The maximum 2a of 0.03 mm took place at the commencement of the principal portion, whose duration was 2.8 sec. The end portion, about 18 sec. in duration, seemed to be composed during the first 3.0 sec. of two extremely small shocks occurring in quick succession. The principal portion of the 2nd earthquake, which was much larger and sensible, lasted 6.5 sec. and began abruptly, the 3rd vibration being the greatest, 2a= 0.09 mm. In the 1st 16.6 sec. of the end portion, the vibrations, which rapidly decreased, continued quick in period: T=0.35 sec. During the remaining 50 sec., the quick vibrations almost disappeared, and the motion consisted principally of slow movements of T=1.4 sec. and of those of T=0.78 sec. Total duration of the 2nd earthquake=78 sec.

Earthquakes of Oct. 5th, 1911. The *earthquake at* 2. 40. 46 *a.m.* This was the largest of the group of the shocks on Oct. 5th and was sensible at Yuno-taira, commencing with the max. vibration, 0.26 and 0.19 mm respectively in the longitudinal and the transverse directions. The motion quickly decreased and was brought to end respectively in 30 and 20 sec. in the two directions. This disturbance was preceded by a small sensible shock, of max. 2a= 0.042 and 0.046 mm respectively in the longitudinal and the transverse components. The *earthquake at* 2. 43. 00 *a.m.* was the next largest on the same day, with the max. 2a=0.10 and 0.11 mm in the long. and the trans. directions. It was preceded 5.4 sec. before, also by a small sensible shock of max. 2a of 0.11 and 0.07 mm in the two components. In the small sensible *earthquake at* 4. 48. 16 *a.m.*, the initial displacement was 0.009 mm directed toward S86° E, the max. 2a being about 0.05 mm in

each component. It seems probable that the origin of this disturbance was situated some distance to the S. of the crater.

Earthquake of Sept. 21st, 1912, at 3.46.34 a.m. : Longitudinal Component. Total duration=42 sec. [Preliminary and principal portion: duration=4.2 sec.] After a very brief preliminary tremor, whose 1st displacement was directed toward the crater, the motion at once reached the max. 2a of 0.15 mm, being most active for the 1st 2.0 sec. For the next 2.2 sec., the motion was much smaller (max. 2a=0.041 mm), but still active. [End portion.] The motion was very small.

The period of the small *pulsatory oscillations*, which prevailed at the time of the earthquake, was about 5.0 sec.

104. *Examples of shocks of larger magnitude observed at Yuno-taira.* Two earthquakes of larger type are mentioned here.

Earthquake of July 24th, 1911, at 5. 56. 44 a.m. This was sensible at Yuno-taira and felt *moderately* at Wakasare, the village of Omai and the town of Naganohara, in the province of Kotsuke, and *slightly* at the towns of Ueda and Komoro, in the province of Shinano, while it was registered as an unfelt disturbance by the ordinary seismographs at the meteorological observatories of Nagano, Maebashi, Osaka, and Tokyo.

Tremor-recorder Diagram. Total duration=about 1 min. The commencement was perfectly sharp, and the first motion was 0.40 mm directed toward N 80.5° E, this probably pointing away from the origin of disturbance. For the 35.5 sec. following the above-mentioned initial displacement, the record consisted of rapid vibrations mixed with a series of the quickly decreasing pendulum movements, which were greatest at first and whose elements were as follows :—

Longitudinal Component: Max. 2a=1.00 mm, T=3.6 sec.;
Transverse „ : Max. 2a=0.76 „ , T=4.1 „ ;

In the succeeding portion, the motion consisted mainly of the gradually decreasing quick vibrations of T=1.0 sec., whose max. 2a was 0.075 mm in each component. Before the earthquake was brought to the end, there began a number of the after-shocks, whose times of occurrence were 5.58.02 ; 5.58.52 ; 6.00.54 ; 6.01.41 ; 6.02.05 a.m.

At Nagano, the principal earthquake was registered as an unfelt disturbance of a total duration of 3^m51^s; preliminary tremor duration=5.7 sec.; max 2a=0.10 mm, T=3.2 sec.

Earthquake of July 24th, 1911 ; *at* 9.11.49 *a.m.* This was sensible at Yuno-taira and was felt as a *moderate* shock at the towns of Ueda, Matsushiro, and Komoro, in the province of Shinano, and at Wakasare and the village of Omae, in the province of Kotsuke, while it was recorded as an unfelt disturbance by the ordinary seismographs at the meteorological observatories of Nagano, Maebashi, Kofu, Kanazawa, Nagoya, Osaka, and Tokyo. The earthquake, whose area of sensible motion was roughly an ellipse of the EW major diameter some 50 km in length, originated probably from a centre near to that of, but was appreciably larger in magnitude than, the preceding shock.

Tremor-recorder Diagram. Total duration=about $2^m\,30^s$. In the longitudinal component, the earthquake indicated apparently no preliminary tremor, but began with a sudden large displacement of about 0.45 mm toward ENE, followed by the counter motion of 1.24 mm, after which the pointer went out of the smoked paper. In the transverse component, the initial displacement was 0.048 mm, directed toward SSE; giving the resultant initial displacement of about 0.78 mm toward N72°E, i.e., directed almost

exactly toward the crater. During the next 13.4 sec., the motion was most active and consisted of the vibrations of T=1.9 sec., max. 2a=1.45 mm, mixed with the much quicker movements. During the next 39.1 sec., there predominated the latter sort of motion, of T=0.78 sec., 2a=0.24 mm. So far may be taken as the principal portion. During the 1st 42.4 sec. of the end portion, the principal period was T=1.3 sec., (2a=0.07 mm). Thereafter the motion became very small: T=2.4 sec., 2a=0.015 mm.

At the meteorological observatory of Nagano, this earthquake was registered as an unfelt disturbance of the following elements: Duration of preliminary tremor=5.8 sec.; total duration=7^m10^s; max. 2a=0.28 mm, T=3.4 sec. The duration of the preliminary tremor corresponds to the radial distance of 5.6×7.48 km=42 km, which is not sensibly different from the actual distance between Nagano and the Asama-yama crater.

After-shocks. The foregoing disturbance was followed at Yuno-taira by two small sensible shocks, whose times of occurrence were respectively 9.15.39 and 9.16.19 a.m. In the 1st of these, the initial displacement was 0.017 mm directed toward S72°E, the preliminary tremor lasting 0.7 sec. In the 2nd shock, the initial displacement was 0.012 mm directed toward S71°E, the preliminary tremor lasting 1.1 sec. It thus appears that these after-shocks originated from points different from the centre of the principal earthquake, probably from the SE neighbourhood of the crater.

105. ***Examples of observation at Ashino-taira and Asama Pasture Ground.*** *Earthquakes of Oct. 12th, 1913, at 8.25.52 a.m.* This was evidently a local shock and was perceived as a slight shaking at Ashino-taira, but not felt at Komoro and the Asama Pasture Ground. The origin of the disturbance seems to have

been situated about 4 km to the west of the crater, namely, some 3 km to the N of Ashino-taira and about 9 km to the WSW of the Asama Pasture Ground.

Tremor-recorder diagram at Ashino-taira. Total duration=92 sec. [ENE-WSW Component.] The preliminary motion lasted only about 0.6 sec.: max. 2a=0.002 mm. Principal portion lasted 16.4 sec. and the motion, which consisted entirely of quick vibrations of T=0.42 sec., max. 2a=0.058 mm, was most active during the 1st 5.6 sec. A maximum group of 2a=0.02 mm, which occurred 18.2 sec. after the commencement of the earthquake, was probably due to a 2nd small shock. In the end portion, the vibrations of T=1.8 sec., max. 2a=0.0047 mm, were mixed with the quick movements of max. 2a=0.0041 mm. [SSE-NNW Component.] The preliminary portion consisted of a single small NNW'ward displacement of 0.0008 mm and of 0.3 sec. in duration. The principal portion, (including the 2nd shock of max. 2a=0.0089 mm), lasted 15.8 sec., and was most active during the 1st 5.4 sec., consisting entirely of the quick vibrations of T=0.38 sec., max. 2a=0.073 mm. In the end portions, small regular vibrations of T=0.45 sec., max. 2a=0.0007 mm, were mixed with those of T=1.1 sec.

Tremor-recorder diagram at Asama Pasture Ground. Total duration=25 sec. [ENE-WSW Component.] The preliminary tremor lasted 1.2 sec.: max. 2a=0.009 mm. During the next 20.5 sec., the motion was most active, and consisted of quick vibrations of T=0.32 sec., max. 2a=0.048 mm, mixed with slower ones of T=0.71 sec. During the next 21.8 sec., the quick movements gradually disappeared, the motion being composed chiefly of the vibrations of T=0.85 sec., whose 2a gradually decreased from 0.025 mm to 0.010 mm. In the subsequent portion the vibrations

were small but regular: T=0.79 sec., max. 2a=0.003 mm. During the principal portion there were traces of slow oscillations of T=4.6 sec. [SSE-NNW Component.] During the preliminary tremor, which lasted 1.2 sec., the motion was practically *nil.* For the next 22.0 sec., the motion was most active and consisted of quick vibrations of T=0.30 sec., max. 2a=0.044 mm, mixed with well defined movements of T=0.78 sec., and grouped into slow oscillations of T=5.4 sec. During the next 23.7 sec., the vibrations were regular: T=0.92 sec., max. 2a=0.016 mm. The subsequent motion was very small.

106. ***Tremors caused by the falling down of rock fragments.*** At half past 8 on the morning of Sept. 12th, 1911, a large quantity of rock fragments rolled down the inner slope of the Kurofu-yama at a place called Tomi-no Kuchi ("mouth of winnowing machine" so named from the resemblance of its form), at an elevation of about 270 m above, and at a direct distance of about 550 m to the WNW of, the Yuno-taira observatory. The motion, which lasted 60.0 sec. and reached the maximum extent of 2a=0.074 mm at 33.3 sec. from the commencement, consisted of quick vibrations of about 0.37 sec. in period grouped into a number of maxima, due probably to a succession of the disturbances at the origin. There was a sort of exceedingly small preliminary tremors for the 21½ sec. preceding the main disturbance, but the termination of the latter was quite abrupt, indicating practically no after-effect.

From examples like these it can be inferred that on the occasion of a strong explosion of the Asama-yama, a lava fragment of moderate dimensions projected with a considerable force from the crater and falling in the vicinity, say, within 200 metres, of the observatory, would leave records of no small magnitude on the smoked paper of the tromometers.