

3.6 sec., or 1.7 sec. longer than in the longitudinal. The two displacements composing the "initial vibration" were much greater in the latter than in the former, the resultants being 0.038 mm toward S55° W and 0.068 mm toward N40°E. Thus, in the present case, the directions of the "inward" and the "outward" movements deviated leftwards from the line joining the observing place with the crater centre respectively by the amounts of 7° and 22°. In the transverse component, large (absolute maximum) regular vibrations set in 17.2 sec. after the earthquake commencement, while in the longitudinal component there was in the same epoch no marked corresponding amplification of the vibrations.

**CHAPTER V. STRONG ASAMA-YAMA EXPLOSIONS  
OBSERVED AT ASHINO-TAIRA.\*  
[TREMOR-RECORDER DIAGRAMS.]**

**40. Explosion of Sept. 21st, 1913, at 1. 50. 59 p.m.** Total duration=97 sec.

*Longitudinal Component.* [Preliminary and principal portions: duration=24.8 sec.] The preliminary motion of 0.0025 mm (duration=0.49 sec.) was followed by the "initial vibration" of  $T=2.2$  sec., composed of the 1st or inward displacement of 0.030 mm (duration=0.97 sec.), and of the 2nd or outward displacement of 0.077 mm (duration=1.22 sec.). The latter was followed by the inward and maximum 2a of 0.093 mm, the two together forming a well defined vibration of  $T=2.43$  sec. Then followed a slow outward displacement (duration=2.1 sec.) of 0.057 mm. So far, for the first 6.1 sec. the motion was gentle, there being practically no superposition of the quick movements.

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\* The times of occurrence of the explosions considered in this chapter are those registered by a tremor-recorder at Ashino-taira.

For the next 14.5 sec., the motion was composed of the vibrations of  $T=1.04$  sec., and max.  $2a=0.034$  mm, mixed with quick movements of  $T=0.36$  sec., and of max.  $2a=0.020$  mm. During this interval, there appeared 4 pendulum oscillations of period of 3.6 sec., and of maximum range of about 0.017 mm. The subsequent motion was smaller. [Sound Shock.] The maximum quick vibrations, which occurred 14.0 sec. from the earthquake commencement, or 12.5 sec. after the end of the 1st displacement of the "initial vibration," may possibly denote the effect of the sound shock. [End portion.] The motion consisted of regular vibrations of  $T=1.45$  sec.,  $2a=0.0048$  mm, mixed with traces of small quick movements.

*Transverse Component.* [Preliminary and principal portions: duration= $23.3$  sec.] The motion was very small for the 1st 1.8 sec., after which a left-hand side displacement of 0.0048 mm (duration= $0.66$  sec.) took place, followed by the counter motion of 0.015 mm (duration= $0.66$  sec.). For the next 4.3 sec. there were  $1\frac{1}{2}$  slow oscillations of  $T=2.9$  sec., of which the max.  $2a$  of 0.064 mm occurred 6.2 sec. after the commencement, these being mixed with smaller movements of  $T=1.2$  sec. During the rest of the principal portion, the motion was much smaller and consisted of the vibrations of  $T=0.87$  sec.,  $2a=0.014$  mm, mixed with some slower movements. [End portion.] Max.  $2a=0.0044$  mm. The effect of the detonation was not indicated.

**41. Explosion of Oct. 9th, 1913, at 1.09.10 a.m.** Total duration= $70$  sec.

*Longitudinal Component.* The preliminary outward motion, was very small (0.0011 mm) and lasted 0.52 sec. The "initial vibration," of  $T=2.3$  sec., was composed of the 1st and 2nd displacements respectively of 0.0045 mm (duration= $1.06$  sec.) and

0.0175 mm (duration=1.21 sec.). Then there followed another slow vibration of  $T=2.6$  sec., composed of the 1st and 2nd displacements respectively of 0.021 mm (duration=1.5 sec.) and 0.011 mm (duration=1.1 sec.). So far, for the 1st 5.6 sec., the motion was slow and free from superpositions of smaller movements. Then there appeared quick vibrations of  $T=0.31$  sec., which were small for the 1st 0.96 sec. ( $2a=0.002$  mm), then became larger ( $2a=0.0076$  mm), and reached the max.  $2a$  of 0.0175 mm after 0.9 sec., or 7.4 sec. from the earthquake commencement. For 15.3 from the moment of appearance of these quick movements, there were mixtures of slow vibrations of  $T=1.4$  sec. ( $2a=0.011$  mm), and other ones. During the rest of the earthquake, the motion consisted of regular vibrations of  $T=1.2$  sec.,  $2a=0.0018$  mm, mixed with traces of quick movements.

*Transverse Component.* During the 1st 14.1 sec. the motion consisted of slow vibrations of  $T=1.6$  sec. ( $2a=0.008$  mm) mixed with some smaller ones. During the next 12.9 sec., small vibrations of  $T=0.38$  sec. were mixed with the slower ones of  $T=0.9$  sec. ( $2a=0.0028$  mm). Thereafter the movements became regular:  $T=1.12$  sec.,  $2a=0.0011$  mm.

**42. Explosion of Oct. 15th, 1913, at 10. 43. 13 p.m.** Total duration= $1^m 34^s$ .

*Longitudinal Component.* The very small preliminary outward motion of 0.0015 mm (duration=0.5 sec.) was followed by the "initial vibration" of  $T=2.2$  sec., composed of the 1st and 2nd displacements respectively of 0.009 mm (duration=1.05 sec.) and of 0.035 mm (duration=1.15 sec.). The effect due to the sound shock, which arrived 14.4 sec. after the commencement of the motion, or 12.8 sec. after the stage corresponding to the moment of the explosion, was markedly larger than the proper earthquake

vibrations, being active ( $2a=0.065$  mm) for 1.15 sec., and lasting for further 1.15 sec. The subsequent motion was small.

*Transverse Component.* The principal vibration periods was  $T=1.01$  sec. (max.  $2a=0.0206$  mm). The sound effect (max.  $2a=0.0225$  mm), which occurred 14.3 sec. after the commencement, lasted 1.7 sec.

**43. Explosion of Oct. 17th, 1913, at 3. 27. 47 p.m.** Total duration= $1^m 56^s$ .

*Longitudinal Component.* [Preliminary and principal portions: duration= $21.8$  sec.] The earthquake began with an inward displacement of  $0.0076$  mm (duration= $1.5$  sec.), followed by the counter motion of  $0.0383$  mm (duration= $1.2$  sec.). For the next  $12.8$  sec. there were 4 large slow vibrations of  $T=3.2$  sec., max.  $2a=0.0663$  mm, with superposition of some quicker movements. During the rest of the principal portion, the motion decreased. [End portion]. The motion was composed of the vibrations of  $T=1.47$  sec. ( $2a=0.0024$  mm), mixed with those of  $T=1.05$  sec., and others.

Both *before* and *after* the earthquake, there were small vibrations of  $T=3.6$  sec., max.  $2a=0.0012$  mm.

*Transverse Component.* [Preliminary and principal portions: duration= $16.6$  sec.] The preliminary displacement was very small and lasted 1.2 sec., after which took a SSE'ward displacement of  $0.0018$  mm (duration= $0.5$  sec.). During the whole remainder of the principal portion, the motion was made up of the vibrations of  $T=1.35$  sec., of which the maximum one of  $0.038$  mm occurred 10.1 sec. after the commencement of the earthquake; these being grouped into slow oscillations of  $T=3.8$  sec. [End portion.] The vibrations of  $T=1.3$  sec. ( $2a=0.0053$  mm) were mixed with others. The period of the *pulsatory oscillations* before and after the earthquake was about 3.8 sec.

**44. Explosion of Oct. 22nd, 1913, at 3. 55. 42 a.m.** Total duration= $1^m 44^s$ .

*Longitudinal Component.* [Preliminary and principal portions : duration= $17.2$  sec.] The preliminary motion lasted  $1.0$  sec. and was practically *nil*. Then took place the "initial vibration" of  $T=2.2$  sec., composed of the 1st and 2nd displacements respectively of  $0.0012$  mm (duration= $0.9$  sec.) and  $0.0069$  mm (duration= $1.3$  sec.). For the next  $11.4$  sec., there were 6 vibrations of  $T=1.9$  sec., of which the 3rd had the greatest  $2a$  of  $0.0275$  mm, and which were grouped into those of double period; the quick superposed movements appearing from about  $4.4$  sec. after the commencement till the end of the epoch here considered. For the next  $9.7$  sec., the motion was composed of the quickly decreasing vibrations of  $T=0.88$  sec., the 1st of which had the max.  $2a$  of  $0.0218$  mm. The subsequent portion of the earthquake motion was composed of the vibrations of  $T=2.1$  sec. ( $2a=0.0042$  mm), mixed with those of  $T=0.98$  sec.

*Transverse Component.* [Preliminary and principal portions : duration= $19.4$  sec.] The motion was very small during the 1st  $1.9$  sec. During the next  $8.3$  sec. there were 3 gradually increasing vibrations of  $T=2.8$  sec., and of max.  $2a=0.0206$  mm, there being superpositions of quicker movements. During the rest of the principal portion the vibrations were smaller:  $T=0.73$  sec.,  $T=1.4$  sec. In the end portion, the vibrations of  $T=1.9$  sec. (max  $2a=0.0012$  mm), were mixed with quicker ones.