

GROUP VI.—*Earthquakes which originated in the Island of
Kiushiu or off its eastern coast.*

Eqke No. 12. August 10th 1898; 10h 0m 50s p.m.

Total duration = about 9½m.

The meizoseismal area, in which buildings were damaged, landslips produced, etc., was a limited portion of the west of the province of Chikuzen (in the northern part of Kiushiu) about 900 km WSW of Tokyo.

Observations at Meteorological Observatories :—

Fukuoka	9h 57m 31s p.m.	Strong.
Izukahara	9. 30. 30	Weak.
Sakai (in Hoki)	9. 55. 28	„
Kumamoto	9. 55. 39	„
Akamagaseki	9. 57. 56	„
Saga	9. 58. 50	Slight.
Miyazaki		„
Matsuyama	9. 57. 0	„
Oita	9. 57. 7	„
Tadotsu	9. 57. 47	„

The P.T. lasted for about 22s and consisted of vibrations of an average period of 3,7s. The beginning was, however, not well defined and a portion of the P.T. was probably lost.

The P.P. The max. 2a was 0,15 mm in each component, the average period being 7,2s.

The E.P. The average period was 3,7s.

Eqke No. 14. August 12th 1898; 8h 38m 42s a.m.

Total duration = about 30m.

This earthquake originated approximately in the same locality as, but was stronger than, the preceding one.

Observations at Meteorological Observatories :—

Saga	8h 34m 29s a.m.	Strong.
Fukuoka	8. 35. 34	„
Sasebo	8. 36. 26	„
Akamagaseki	8. 36. 8	Weak.
Sakai (in Hoki)	8. 34. 49	„
Oita	8. 36. 12	„
Kumamoto	8. 36. 25	„
Izugahara	8. 36. 13	Slight.
Tadotsu	8. 36. 55	„
Fukui	8. 38. 15	„

The P.T. lasted for 122s. The average period was 3,7s.

The P.P. began with 15 well defined vibrations of an average period of 3,7s, whose max. 2a was 0,2 mm in the EW and 0,1 mm in the NS component. Then followed 30 slower waves of an average period of 7,0s, whose max. 2a was 0,4 mm in the EW and 0,2 mm in the NS component.

The E.P. The average period deduced from two successive groups of 60 vibrations taken at the end was as follows :—

$$\left. \begin{array}{l} 7,0s \\ 8,1 \end{array} \right\} \begin{array}{l} \text{(General mean)} \\ 7,6s. \end{array}$$

Eqke No. 66. December 4th 1898 : 1h 45m 32s a.m.

Total duration = about 19m.

The earthquake was felt strongly in the northern part of Kiushiu, the epicentre being at about long. 139° E and lat. 33° N.

Observations at Meteorological Observatories :—

Oita	1h 44m 28s a.m.	Strong.	{ Motion quick, accompanied by vertical movements ; pendulum clocks stopped.

Saga	.. ..	1h 35m 38s a.m.	Strong.	Duration long.
Kumamoto	..	1. 49. 27	„	{ Motion quick, accompanied by vertical movements; houses shaken.
Hiroshima	..	1. 44. 00	Weak.	Motion gentle.
Miyazaki	..	1. 44. 00	„	{ Accompanied by vertical motion; pendulum clocks stopped.
Kagoshima	..	1. 45. 3	„	Houses shaken.
Fukuoka	..	1. 45. 20	„	{ Motion quick, accompanied by vertical motion; houses shaken.
Tadotsu	..	1. 45. 27	„	{ Accompanied by sound; houses shaken.
Kochi	.. ..	1. 45. 40	„	Houses shaken.
Kure	.. ..	1. 46. 0	„	Duration long.
Akamagaseki.		1. 46. 26	„	Duration short.
Osaka	.. ..	1. 47. 33	„	Duration long.
Matsuyama	..	1. 49. 50	„	Houses shaken.
Fukui	.. ..	1. 45. 27	Slight.	
Tsu	.. ..	1. 46. 25	„	
Sakai	.. ..	1. 45. 30	„	Motion gentle.
Yagi	.. ..	1. 46. 48	„	„
Hamada	..	1. 47. 0	„	{ Motion quick, accompanied by vertical movements.
Nagasaki	..	1. 50. 16	„	Duration long.
Okayama	..	1. 52. 4	„	
Tokyo	.. ..	1. 57. 0	„	

(NS component).

The P.T. The beginning and end of the diagram were obscured by small and quick P.O., whose max. 2a was 0,04 mm and whose average period was 4,4s (measured immediately before the earthquake). The

duration of the P.T. was about 1m 24s. Towards the end there were traces of distinct waves of an average period of 8,2s.

The P.P. whose duration was about 9m began with 7 oscillations of an average period of 9,3s; of these the 4th was the (abs.) maximum, its 2a being 1,0 mm. For the next 1m 11s predominating waves had an average period of 4,4s, the max. 2a of 0,55 mm occurring at 3m 20s from the commencement of the earthquake. For the next 7m 50s the motion was more or less active, consisting essentially of waves of an average period of 8,5s.

The E.P. The average period was 7,5s.

(EW component).

The P.T. lasted for about 112s. There were traces of vibrations of an average period of 9,0s.

The P.P., whose duration was about 9m 18s, began with vibrations of an average period of 6,5s (max. 2a=0,7 mm), superposed on slower ones of an average period of 9,4s (max. 2a=0,55 mm). In the subsequent part the predominating period was 7,7s.

The E.P. The average period was about 8,0s.

Eqke No. 112. March 24th 1899; 1h 2m 35s p.m.

Total duration = 1h 9m.

The earthquake was felt strongly in the eastern half of Kiushu, the origin being probably situated off its eastern coast, at about longitude 132° E and lat. 32° N.

Observations at Meteorological Observatories :—

Miyazaki	..	1h 0m 0s p.m.	Strong.	} Motion quick, accompanied by vertical movements; houses shaken.
Kagoshima	..	1. 0. 35	..	
Oita	..	1. 0. 47	..	} Accompanied by sound and vertical motion; pendulum clocks stopped.

Tokushima	..	0h 57m 30s p.m.	Weak.	{ Motion quick, accompanied by vertical movements.
Kumamoto	..	1. 0. 51	..	{ Motion quick, accompanied by vertical movements; houses shaken.
Tadotsu	.. ..	1. 1. 22	..	.. .. ..
Fukuoka	.. ..	1. 1. 25	..	Houses shaken.
Akamagaseki	..	1. 1. 33	..	{ Accompanied by vertical motion.
Hiroshima	..	1. 2. 0	..	Duration long.
Sakai	.. ..	1. 3. 15	..	Motion gentle.
Nagasaki	.. ..	1. 3. 44	..	Duration long.
Oshima	.. ..	1. 4. 20	..	.. ..
Tsu	.. ..	0.57. 35	Slight.	
Fukui	.. ..	0.59. 59	..	Duration long.
Osaka	.. ..	1. 0. 6	..	.. ..
Saga	.. ..	1. 0. 13	..	.. ..
Wakayama	..	1. 1. 2	..	Motion gentle.
Kochi	.. ..	1. 1. 36	..	.. ..
Yagi	.. ..	1. 1. 40	..	Duration long.
Kure	.. ..	1. 1. 45	..	Motion gentle.
Matsuyama	..	1. 2. 10	..	
Nagano	.. ..	1. 2. 35	..	
Kyoto	.. ..	1. 2. 45	..	
Izugahara	..	1. 2. 50	..	
Nagoya	.. ..	1. 2. 50	..	{ Accompanied by vertical motion.
Gifu	.. ..	1. 2. 54	..	Motion gentle.
Okayama	..	1. 3. 33	..	.. ..
Tokyo	.. ..	1. 4. 57	..	

(NS component).

The P.T., which lasted for 2m 2s, consisted of small quick vibrations

of an average period of 2,4s. During the last 44s, however, which may probably be taken as the 2nd P.T., there were larger vibrations of an average period of 3,7s. Throughout this epoch there were well defined traces of slower waves of an average period of 8,4s.

The P.P., whose duration was about 15m, began with nine regular well pronounced vibrations (max. $2a=0,9$ mm) lasting together for 1m 21s and having an average period of 9s. For the next 1m 39s, the motion consisted of slow undulations of an average period of 16,5s, the max. (abs.) $2a$ being 1,3 mm. The motion remained small during the next 2m 12s, and then took place two conspicuous undulations ($2a=0,6$ mm) of an average period of 15,5s. After this the motion showed a series of alternations of max. and min. groups, the average interval between successive maxima being 1m. Towards the end, the average period was 9,9s.

The E.P. The average period, deduced from two successive groups of 50 vibrations, was as follows:—

$$\begin{array}{r} 9,0s \\ 8,6 \end{array} \left. \vphantom{\begin{array}{r} 9,0s \\ 8,6 \end{array}} \right\} \begin{array}{l} \text{(General mean)} \\ 8,8s. \end{array}$$

(EW component).

The P.T. lasted for 1m 40s. The principal average period was at first 2,9s, but towards the end 8,8s.

Then P.P. began with two slow undulations of an average period of 26,5s, of which the first had a max. $2a$ of 1,2 mm. Superposed on these there were well defined waves (max. $2a=0,8$ mm) of an average period of 8,4s.

Eqkes Nos. 236 and 237. November 25th 1899; 3h 45m 24s a.m. and 3h 58m 48s a.m.

Total duration=2h 13m.

The first of these two earthquakes was the greatest which shook Kiushiu in recent years. In the two provinces of Bungo and Hiuga a few houses were overthrown and the ground was slightly cracked. The origin was probably inland, at about long. $131^{\circ}\frac{1}{4}$ E and lat. $32^{\circ}\frac{3}{4}$ N.

Observations at Meteorological Observatories:—

Oita	.. ..	3h 43m 4s a.m.	Strong.	{ Houses damaged ; followed by minor shocks.
Kumamoto	.. ..	3. 43. 29	„	{ Motion quick, accompanied by vertical movements ; houses shaken.
Saga	.. ..	3. 46. 12 (?)	„	
Miyazaki	.. ..	3. 43. 4	„	{ Walls cracked ; followed by minor shocks.
Kagoshima	... ..	3. 43. 21	„	Houses shaken.
Matsuyama	.. ..	3. 42. 12 (?)	Weak.	
Nagasaki	.. ..	3. 44. 33	„	{ Motion quick ; houses shaken.
Osaka	.. ..	3. 45. 17	„	Duration long.
Fukuoka	.. ..	3. 48. 50	„	{ Accompanied by vertical motion.
Oshima	3. 41. 0	„	Houses shaken.
Hiroshima	3. 42. 20	„	
Iida	3. 49. 20 (?)	Slight.	
Kochi	3. 45. 38	„	
Tokyo	3. 45. 41	„	
Mito	3. 43. 20	„	
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Oita	3h 55m 7s a.m.	Strong.	{ Motion quick ; houses shaken.
Saga	3. 56. 18 (?)	„	
Kumamoto	3. 54. 10	„	{ Motion quick, accompanied by vertical movements.
Fukuoka	... ..	3. 50. 43	Weak.	{ Accompanied by vertical motion ; houses shaken.
Kagoshima	... ..	3. 55. 0	„	Houses shaken.
Osaka	... ..	3. 56. 52	„	Duration long.

Hiroshima	..	3h 54m 10s a.m.	Slight.	} Accompanied by vertical motion.
Nagasaki	..	3. 55. 10	„		Houses shaken.

The earthquake was recorded by the usual EW (*A*-machine) and the NS component (*B*-machine) pendulums as well as by the large long-period horizontal pendulum (*C*-machine). The diagram from the last-named of these three pendulums was taken very satisfactorily and shall therefore be first described.

(EW component; C machine).

The P.T., whose duration was 1m 42s, consisted of thirteen vibrations of an average period of 8,2s, the max. 2a being 0,5 mm. There were also some slight traces of very slow undulations.

The P.P. began with an abrupt displacement of 2,2 mm towards W. Then followed a large undulation (a) of period 35,4s, which consisted of the following two movements :

6,4 mm towards E,
6,5 mm „ W.

During the next 1m 55s there were six undulations, giving an average period of 23s. These slow waves which together lasted for 3m were superposed with small quick vibrations, apparently continued from the P.T. From 3h 49m 53s, that is 4m 38s after the beginning of the earthquake, quicker waves became prominent; the motion consisting essentially of the following two types (1) and (2):—

- (1) vibrations of an average period of 8,0s whose max. 2a of 2,7 mm occurred at about 3h 51m 15s.
- (2) undulations of an average period of 17,0s, whose max. 2a (b) of 6,4 mm occurred at 3h 49m 25s; forming the last but one wave of the P.P. or at 2m 28s after the commencement of the P.P.

The exact commencement of the 2nd earthquake was obscured by the E.P. of the first. The long period maximum undulation, however, began

to appear at 3h 58m 39m, that is 11m 42s after the occurrence of the corresponding wave in the first earthquake; the (max.) $2a$ (a') being 2,9 mm and the period 31,3s. Then followed, six well defined waves of an average period of 23s; the slow undulations together lasting for 3m. The absolute max. motion (b') ($2a=3,6$ mm), whose period was 17,6s, occurred at 3h 15m 56s, or at 2m 32s after the commencement of the P.P. and was the last but one undulation of the P.P.

The two earthquakes were thus exactly similar to each other; there being in each case first a maximum undulation of a very slow period (a, a'), and subsequently another maximum wave (b, b') whose period was about half of that of the first. The time intervals between a and b and between a' and b' were respectively 2m 3s and 2m 2s; while the time differences between a and a' and between b and b' were each 11m 35s.

In the E.P. of the 2nd earthquake the average period was 8,1s (measured from 80 vibrations).

(NS component).

The P.T. which lasted for 2m 6s and which began with a displacement of 0,1 mm towards S, consisted at first of small vibrations (max. $2a=1,3$ mm) of an average period of 8,2s. At 49s from the commencement there appeared two well pronounced undulations of an average period of 23,5s; this was followed by a third vibration of a period of 33,3s.

The P.P. began with an abrupt motion of 1,8 mm towards S, its counter motion being 5,2 mm towards N. This was followed by two undulations of an average period of 25s, whose max. $2a$ was 9,6 mm. After this, strong pendulum oscillations set in, the pointer having been thrown out of the record-receiver. At 5m 30s from the beginning of the earthquake, the pointer came of itself again on the latter and thereafter record was taken till the end of the motion.

The beginning of the second earthquake was obscured by the proper pendulum oscillations in the E.P. of the first earthquake. The maximum pendulum motion, however, occurred at 4h 0m 45s, that is at about 12m after the corresponding movement in the first earthquake. The active pendulum oscillations ceased at about 4h 8 $\frac{3}{4}$ m.

The E.P. The average period, deduced from two groups of 60 vibrations, taken at about 4h 33m, was as follows:—

$$\begin{array}{r} 10,6s \\ 10,5 \end{array} \left. \vphantom{\begin{array}{r} 10,6s \\ 10,5 \end{array}} \right\} \begin{array}{l} \text{(General mean)} \\ 10,6s. \end{array}$$

(EW component).

The P.T., which began with a motion of 0,2 mm towards W, consisted at first of vibrations of an average period of 8,3s. At 36s from the commencement three pendulum oscillations took place.

At 1m 48s from the commencement there appeared a large undulation (probably mixed in part with the pendulum oscillation) whose 2a was 7,9 mm and whose period was 32,5s. The next movement was still larger and the pointer was driven out of the record-receiver. After 23m the pointer came back of itself again on the record-receiver.
