

**28. Observation of Aftershocks Carried out in  
Imaichi District, Tochigi Prefecture.**

By the Earthquake Research Institute.

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On the morning of December 26, 1949, a strong earthquake took place in the vicinity of Imaichi, Tochigi Prefecture, and considerable damage was caused in that area. The following day, the members of the Earthquake Research Institute hurried to the district with many instruments to set up a temporary seismological net-work there. Five points were chosen as the stations, that is, Funyū, Imaichi, Kanuma, Nikkō and Nishi-ōashi. Each station began its operation on Dec. 28, except Nishi-ōashi, where the observation was commenced on Dec. 31. The location of the stations and the instruments installed there are shown in Fig. 1 and Table I.

Table I. List of instruments installed at the stations  
and the period of observation.

Station	Constants of seismographs			The period of observation from to
	Component	Natural period	Magnification	
Funyū	E-W	0.1 sec.	187	Dec. 28, 1949 Jan. 10, 1950.
	N-S	0.1	187	
	U-D	0.1	206	
Imaichi	E-W	1	230	Dec. 28 Dec. 30 Dec. 28 Jan. 10
	E-W	6	30	
	N-S	0.1	120	
Kanuma	E-W	6	30	Dec. 28  Jan. 8
	N-S	6	30	
	N-S	0.1	120	
Nikkō	E-W	6	30	Dec. 28 Jan. 28
	N-S	0.1	120	
Nishi-ōashi	E-W	1	230	Dec. 31  Jan. 6
	N-S	1	230	
	U-D	0.1	220	

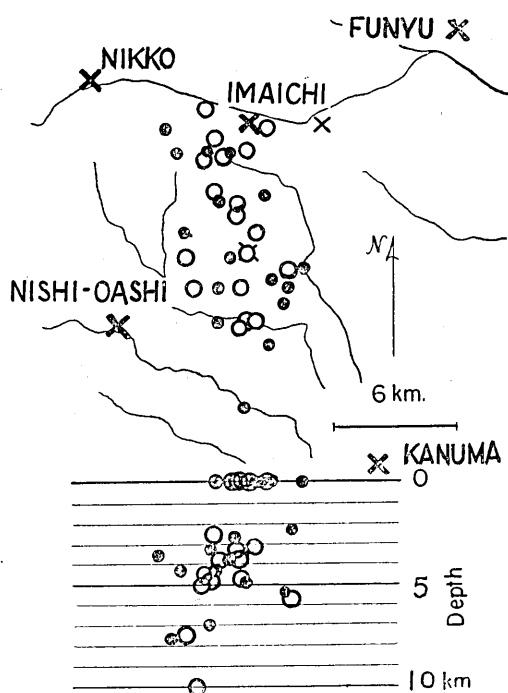


Fig. 1. Distribution of hypocenters.

- : Foci determined by P-S times obtained at four stations.
- : Foci determined by P-S times obtained at three stations.
- × : Stations.

The earthquake was accompanied by so many aftershocks that some people in Imaichi could count more than 18 fairly strong earthquakes during the half an hour just following the main shock. Although our party missed the most active period following just after the main shock, with the seismographs brought there we could record many numbers of aftershocks in the earlier period of our observation. The aftershocks were recorded most frequently at the stations Imaichi and Nishi-ōashi, but not so often at station Kanuma, the most distant station from the damaged region. At station Nikkō we succeeded in catching a good number of shocks, and at station Funyū, in spite of its distant position, numbers of aftershocks were recorded with acceleration seismographs, which were twice as sensitive as those of the other stations. For instance, the daily number of aftershocks, recorded at stations Imaichi and Nikkō are given in Fig. 2, in which we numbered aftershocks whose maximum amplitudes exceed 2 mm on the record of the acceleration seismograph.

The aftershocks were distinguished by short P-S times (the name we gave

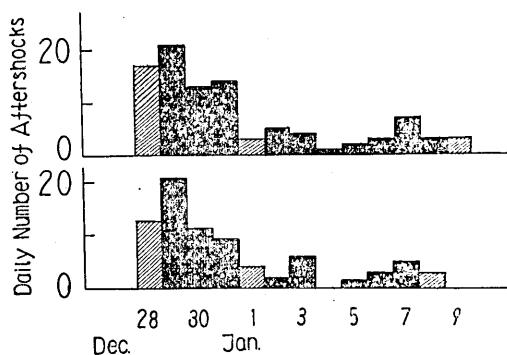


Fig. 2 Daily number of aftershocks.  
Upper: Imaichi. Lower: Nikkō.

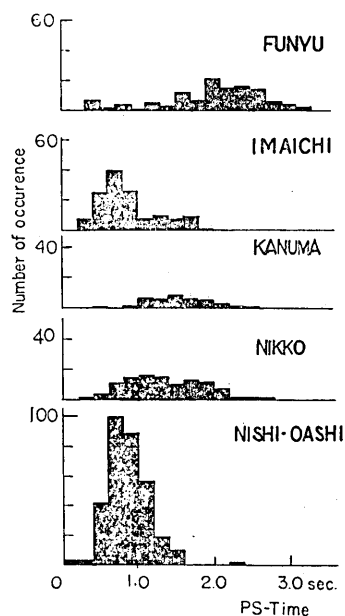


Fig. 3. Frequency distribution of P-S times.

to the duration time of preliminary tremor for the sake of convenience) and rapid vibration as may be seen in Fig. 5, and sometimes they were accompanied by earthsound. Frequency distribution of P-S times observed at our stations are shown in Fig. 3, in which we found that P-S times are quite short in general and even at station Kanuma, no P-S times exceeding 4 seconds were observed.

It was not always easy to find correspondence between seismograms obtained at different stations, because in such a case when very small aftershocks occurred frequently in the neighbourhood of a station, they could not be recorded at distant stations notwithstanding the remarkable amplitude recorded at the nearer station.

To determine the position of the hypocenters of the aftershocks, the ordinary method in which P-S time is used was employed. In this case, the first requisite is to evaluate  $k$  in the formula  $D=kt$ , in which  $D$  is the hypocentral distance,  $t$  the P-S times, and  $k$  the constant. If we obtain P-S times at four stations, we can calculate the value of  $k^{1)}$ . The data used for this purpose are shown in Table II. We adopted as the mean value of them  $7.1 \pm 0.4$ , where the value of  $k$  was considered as free from focal depth

1) For instance, see T. HAGIWARA, *Bull. Earthq. Res. Inst.*, 18 (1940), 255.

Table II. List of the aftershocks, whose hypocenters have been determined.

Commencement time <sup>*)</sup>			P—S time					k	Depth	
d.	h.	m.	Funyū	Imaichi	Kanuma	Nikkō	Nishi- ōashi			
			sec.	sec.	sec.	sec.	sec.	km		
Dec. 29	0	36	2.2	1.0		1.9			0	
	1	09	2.2	1.3	1.7	2.1		7.1	6.0	
	1	36	3.1		1.2	2.6			4.9	
	3	12		1.2	1.4	2.0			2.3	
	5	39		1.2	2.8	1.3			7.8	
	7	24		0.9	1.8	1.6			2.8	
	22	45		1.5	1.5	2.2			5.5	
	23	08		0.6	2.5	1.2			3.8	
	23	41			1.1	2.2	1.4		4.4	
	:30	18	17	2.0	0.8	2.4	1.2		7.5	5.2
31	0	38	2.5		1.8	1.8			4.6	
	2	49	1.8	0.4		1.5			0	
	18	49	2.2		2.0	1.7	1.1	6.1	0	
	18	52	2.3		1.9	1.8	1.1	6.9	4.9	
	20	46	2.5		1.1		1.0		0	
	Jan. 1	12	37	1.8	0.7	2.6	1.0		7.7	4.8
	2	0	23	2.6	1.4			0.7		0
		1	37	2.9	1.8	2.2	2.1		7.3	10.0
		6	07	1.8	0.5	1.9	1.2	1.2	7.8	3.3
		18	53	1.8	0.6		1.1	1.4	7.6	4.0
19		17	2.0	0.5		1.1	1.6	6.6	2.7	
19		51		1.0		2.0	1.3		0	
23		30	2.9	1.6	1.5		0.9	6.2	0	
23		59	2.0		2.0	1.4	1.1	7.1	0	
3		11	44		1.5	1.5	2.2	1.1	6.6	3.3
		15	36	1.6	0.5	2.2	1.2	1.3	7.8	4.4
	15	38		0.8		0.8	1.5		3.9	
	15	46	1.9	0.8		1.2	1.2	8.0	5.0	
	23	36	2.5	1.2	1.7	1.9		6.8	3.9	
6	6	06		0.7	2.2	1.3			3.3	
	8	31	1.5	0.2	2.5	1.2	1.6	7.2	0	
7	17	59	2.2	1.1		1.4			7.2	
	19	25	2.8	1.4	1.4	2.1		6.5	0	
8	3	34	2.6	1.4	2.2	1.7		7.3	7.9	

Mean value of  $k=7.1 \pm 0.4$ 

\*) For commencement times the date at Funyū were adopted, in most cases.

(Fig. 4). After  $k$  was evaluated, the hypocenters can be determined by  $P-S$  times obtained at only three stations. Fig. 1 shows the epicentral distribution determined by the above method.

As will be seen in the figure, the aftershocks are confined to a small area, 15 km long and 6 km wide, somewhat elongated in the N-S direction, with Mt. Keimei located in the centre of the area. As to the focal depth, aftershocks occurred most frequently in shallower place, 0-5 km beneath the surface, and none of them could be found in depth exceeding 10 km. In Fig. 1, the hypocenters are projected on a vertical plane,

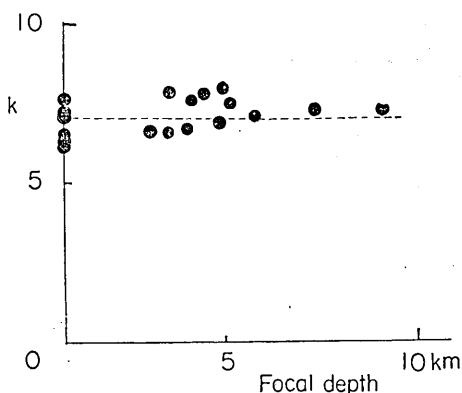


Fig 4. Valued of constant " $k$ ."

and we find in the figure that the aftershocks with large focal depth are generated, in some measure, in the western side of the region.

Shifting of seismic active area with the lapse of time, which was often discussed in the studies on the characters of seismic activity, could not be seen in the present case. The push-pull distribution of the initial motion will be described in a separate paper.<sup>2)</sup>

#### Concluding Remarks.

The outlines of the observation of aftershocks carried out in the Imaichi district were reported in this paper. More details related to the characters of aftershocks observed at each station, will be reported in separate papers, by the persons in charge of that station.

The present observation owes much to many persons who cooperated with the members in carrying out the work, and the authors wish to express their hearty thanks to all of them.

In conclusion, the members of the party are listed as follows:

- (Station Funyū) S. Miyamura, T. Akima and T. Chigira,
- (Station Imaichi) T. Hagiwara, T. Rikitake and K. Kasahara,
- (Station Kanuma) F. Kishinouye, and R. Ikegami,
- (Station Nikkō) K. Kanai, T. Tanaka and T. Suzuki,
- (Station Nishi-ōashi) S. Omote and T. Fukuda.

2) T. HAGIWARA and K. KASAHARA, *Bull. Earthq. Res. Inst.*, 28 (1950), 593.

## 28. 今市地震餘震觀測報告

地震研究所

今市地震發生直後より約2週間に亘り、同地方において餘震の出張觀測が行われた。觀測點には船生、今市、鹿沼、日光及び西大芦が選ばれ、研究室單位に各々一點の業務を擔當したが、こゝに報告するのはその一般的な結果である。

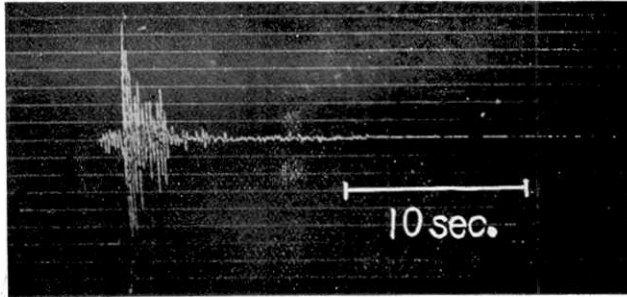
震源の決定された餘震は期間中に34を數えたが、今回の餘震は極めて地表近く且局限された區域内に多く起つてゐる模様で、その中心は落合村の鷓鳴山附近と推定される。

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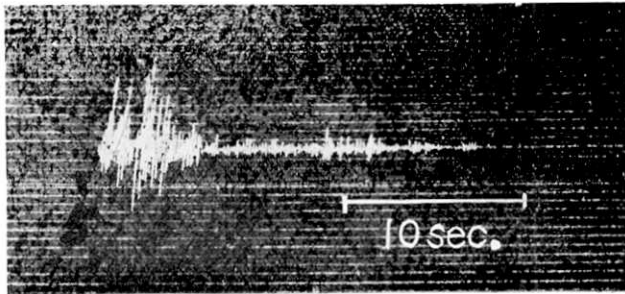
Earthquake of 3<sup>h</sup>34<sup>m</sup>,  
Jan. 8, 1950.  
(1.2× the actual)

Funyū, Acceleration seismograph, *N-S* Component.



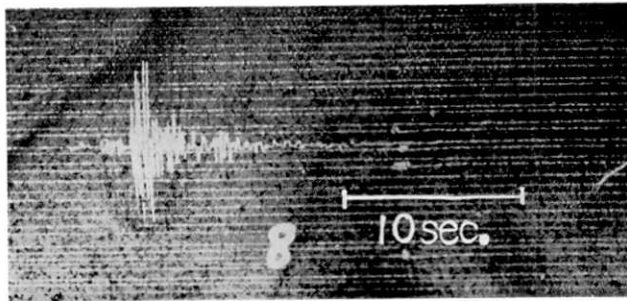
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(2.4× the actual)

Imaichi, Acceleration seismograph, *N-S* Component.



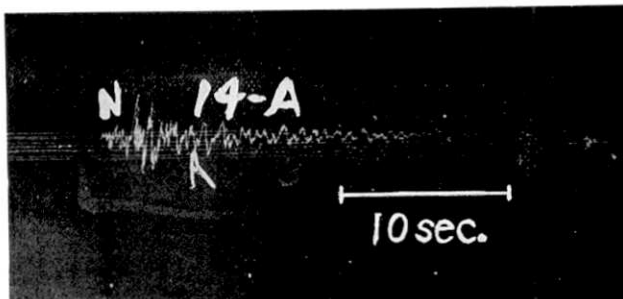
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(2.4× the actual)

Kanuma, Acceleration seismograph, *N-S* Component.



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(2.4× the actual)

Nikkō, Acceleration seismograph, *N-S* Component.



Earthquake of 8<sup>h</sup>31<sup>m</sup>,  
Jan. 6, 1950.  
(2.4× the actual)

Nishi-ōashi, Displacement seismograph, *N-S* Component.