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27. Two Periodic Activities of Microearthquakes near Kumamoto, Southwestern Japan

—Results of a Temporary Observation in November 1978—

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Abstract

A tripartite microseismic network was installed near Kumamoto in Kyushu, southwestern Japan, during the period of November 15-19, 1978. Seismic activity was low underneath Kumamoto City in comparison with the surrounding areas. The distribution of epicenters was diffuse and did not appear to correlate with any of the known major faults in the area. During the period of observation, an M=1.3 earthquake and its aftershocks were observed under the Shimabara Bay, and a periodic earthquake swarm (the largest M=1.5) occurred near Ueki. The main shock and recorded aftershocks (except one out of four) of the Shimabara Bay earthquake occurred at high tide in the Bay. P wave first motions suggested a possible normal faulting. Consequently these shocks may have been triggered by an increase in earthquake-generating stress caused by tidal loading. The activity associated with the Ueki swarm occurred in cycles of about 20 hours. The activity in each cycle was characterized by the occurrence of minor shocks in the early stage, increase in magnitude in the successive stage, and finally the largest shock which was followed by a quiescent period of about 12 hours.

1. Introduction

A tripartite network of microearthquake observation was installed near Kumamoto in Kyushu Island, southwestern Japan, during November 15–19 in 1978. The network was installed for the following three reasons:

(1) Remarkable earthquake swarms were observed in the northern part of Kumamoto Prefecture (Fig. 1; MITSUNAMI and KUBOTERA, 1977; Seismic Activity Monitoring Center, 1978) prior to the largest M=5.2 earthquake of June 28, 1977, that occurred near Ueki, about 15 km north of Kumamoto City. It was interesting to observe the characteristics of seismic activity in this area one year after these marked sequences.

(2) The Kumamoto area (i. e. Kumamoto City and sorrounding areas)

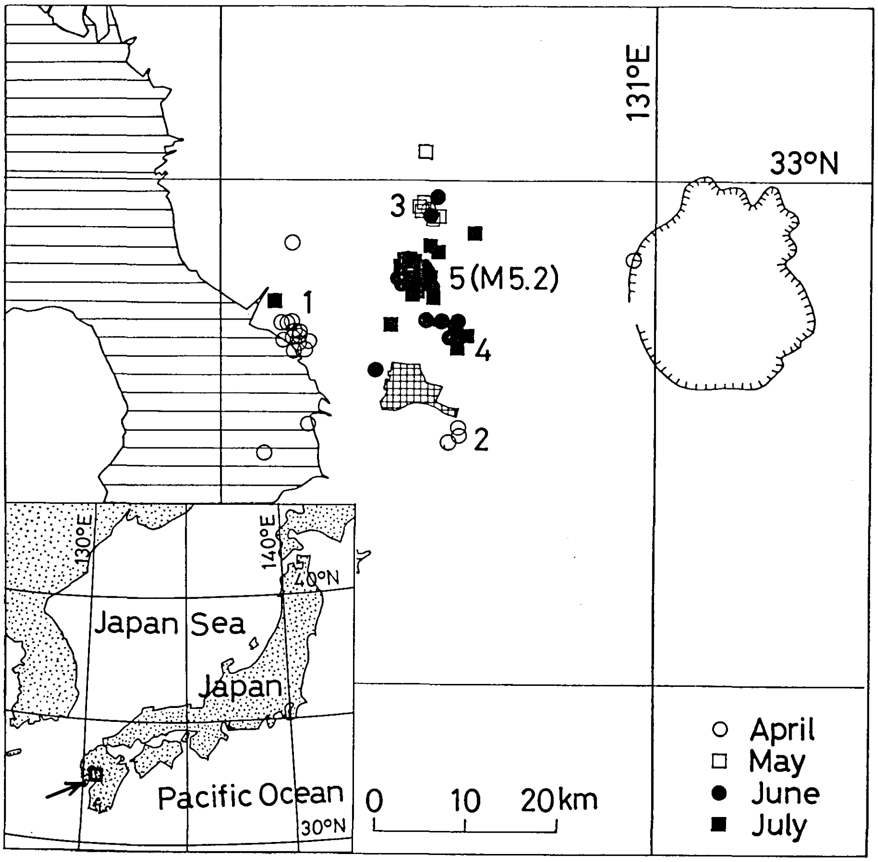

Fig. 1. Epicentral distribution of the maked sequence of the swarm activity near Kumamoto during April-July, 1977 (MITSUNAMI and KUBOTERA, 1977). Numerals represent the number of areas which migrated successively. The largest earthquake (M=5.2) occurred on June 28 in the area 5.

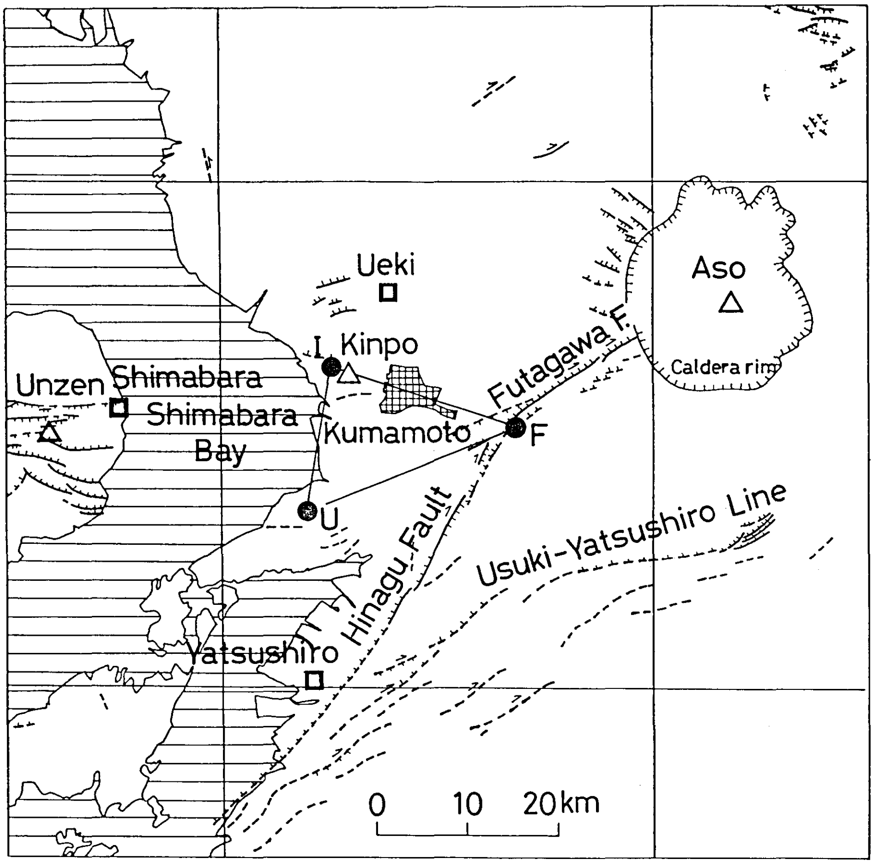

Fig. 2. Locations of the temporary stations (solid circles), confirmed and inferred active faults (solid and broken curves, respectively; HUZITA et al., 1980), and volcanoes (triangles). The tripartite network was installed to cover the urban area of Kumamoto City (checked area).

is adjacent to some major faults (Fig. 2). The Futagawa-Hinagu fault system is known to be active during the Quatnrnary and strikes in a northeasterly direction (e. g., OKADA, 1973; WATANABE et al., 1979; HUZITA et al., 1980). The Usuki-Yatsushiro Tectonic Line has been interpreted to be a part of the Median Tectonic Line (e. g. TERAOKA, 1970). Some topographic lineations along this line have also been cited as possible active faults (e. g., OKADA, 1973; HUZITA et al., 1980). It was desired to see if microearthquake activity is associated with these features.

(3) The Kumamoto area is frequented by earthquakes of magnitude 4-6 in JMA's (Japan Meteorological Agency) scale. Kumamoto City is presently one of the most crowded cities in southwestern Japan with a population of about 500,000. Only one permanent seismograph station is

Table 1. Location of the temporary seismic stations.

Station name	Code	Longitude	Latitude	Height	Component
East (Funanoyama-S)	F	130°50′15.6″	32°45′12.0″	80 m	V
Southwest (Uto-Abiku)	U	130°35′37.3″	32°40′32.2″	60 m	V
Northwest (Iwato-Kannon)	I	130°37′25.0″	32°49′00.7″	190 m	V, H (N60°E)

located in this area. Hence, in terms of seismic risk, the installation of a microearthquake network allowed us more detailed knowledge of the seismicity of the region.

Accordingly, temporary stations were set up to enclose Kumamoto City triangularly from east (south of Mt. Funano; near the trace of the Hinagu fault), northwest (Iwato-Kannon; the western foot of Mt. Kinpo) and southwest (Uto-Abiku in Uto Peninsula), with spans of 16–25 km (Table 1). Since the present work was quite short in installation period,

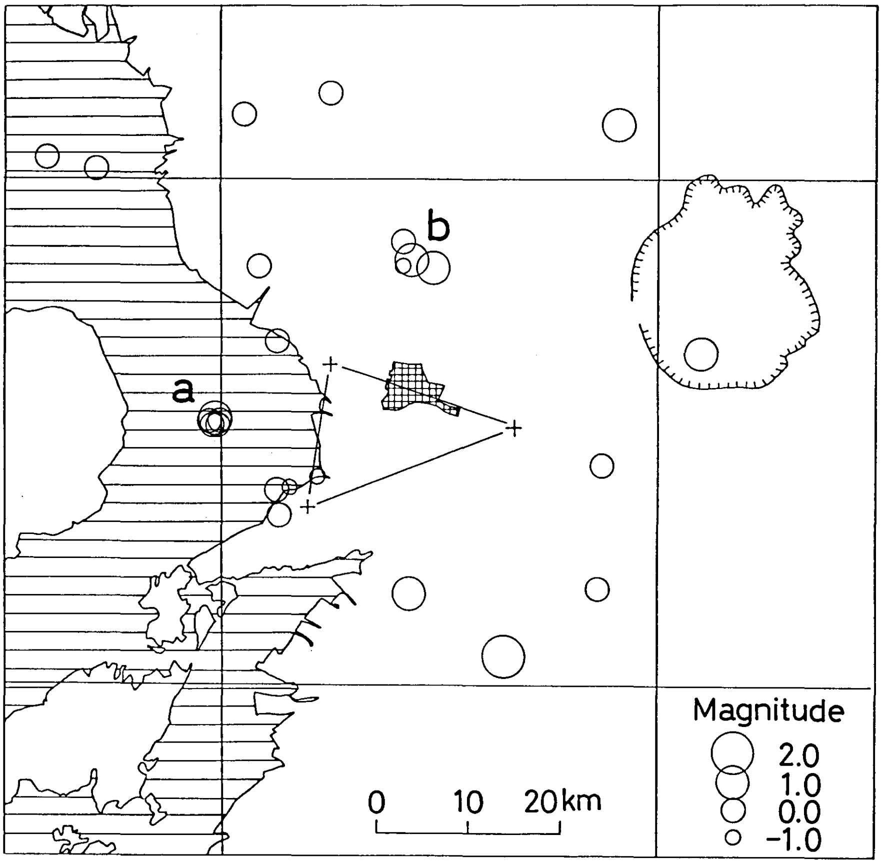

Fig. 3. Epicentral distribution obtained by the present survey during 16:00 on November 16 - 13:00 on November 18, 1978 (Japanese Standard Time).

it is a preparatory one for later studies especially for the purposes of (2) and (3).

2. Data Analysis

The hypocentral determination was carried out assuming a semi-infinite crust with P wave velocity of 6.0 km/sec and Vp/Vs ratio of 1.732. By using the Vp/Vs ratio and S-P times obtained from the horizontal component at the Northwest station, the origin time was estimated. Then the coordinates of the hypocenter were computed to satisfy the P arrivals. Since the velocity structure in this area has not been studied in detail, the hypocentral determination may be considered as a prelimi-

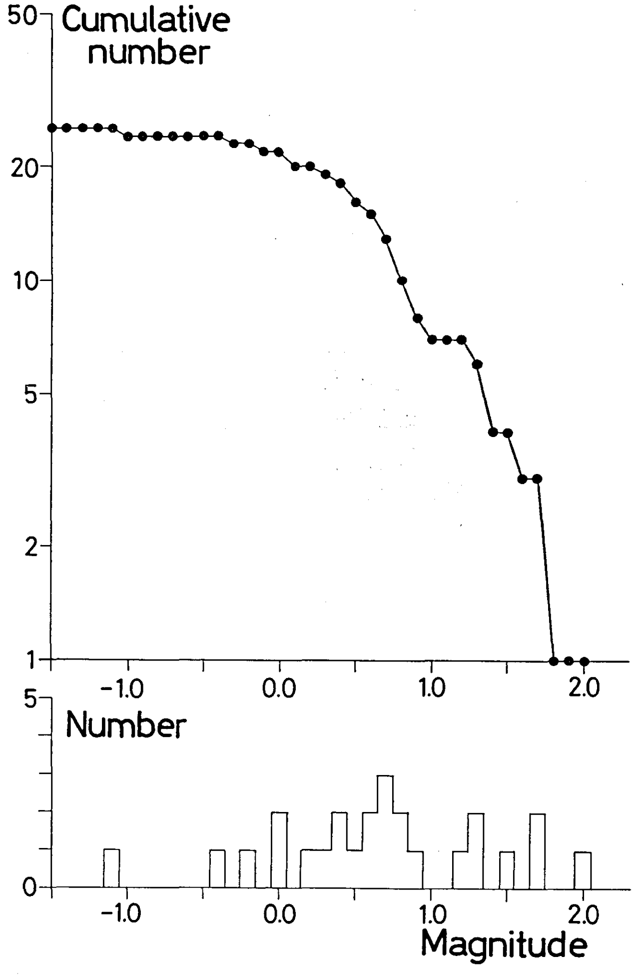

Fig. 4. Relation between magnitudes and numbers of the earthquakes located in Fig. 3.

nary one. The present location, however, should be accurate enough to delineate any general trends in the hypocentral distribution.

The magnitude was estimated by a preliminary relation; $M=3.0 \log_{10}(F\text{-}P)-3.6$. Here F-P is the duration of oscillation observed at the East station. This relation was assumed so as to approximately agree with those by WATANABE (1971) and KANBAYASHI and ICHIKAWA (1977), both of which gave a magnitude using a maximum velocity amplitude. According to the present scale, the magnitudes of the earthquakes shown in Fig. 3 range 2.0 to −1.1. The relation between the cumulative number of the shocks and their magnitude represents a deviation from a general linear trend in a magnitude range smaller than 0.5 (Fig. 4). It suggests the detectability of the present observation; events smaller than 0.5 in magnitude were able to be located only in a limited cases.

3. Results

Hypocenters were determined for 30 of the earthuakes that occurred during almost two days from 4 p.m. on November 16 to 1 p.m. on November 18 (in Japanese Standard Time=GMT+9 hours), when all three stations were in operation. The epicentral distribution of these shocks is shown in Fig. 3 and Table 3, excepting the shocks which were located outside of the figure. Depths of the located events were mostly shallower than 15 km, if they were not far from the tripartite network (Table 3). All the recorded P arrivals and S-P times are given in Table 2.

In Fig. 3, no seismic activity appears to apparently related to the major fault systems in Fig. 2, although a few shocks did occur near the Futagawa-Hinagu fault system or the Usuki-Yatsushiro Line. A relative lack of activity is also seen under the urban area of Kumamoto City as compared with the surrounding regions. This may be, of course, simply a result of the short term of the observation.

Fig. 3 also shows two clusters of activity. One of these is under the Shimabara Bay (a) and the other near Ueki (b). The former was a main and aftershock sequence, and the latter a swarm type activity. Each of these occurrences will be described in detail.

(a) Activity under the Shimabara Bay

One of the most remarkable occurrences during the present observation was the activity under the Shimabara Bay, a part of the Ariake Sea. The main shock occurred at 21:31 on November 16 with a magnitude of 1.3. The focal depth was estimated to be about 6 km. Foreshocks were not observed. Four aftershocks followed the main shock

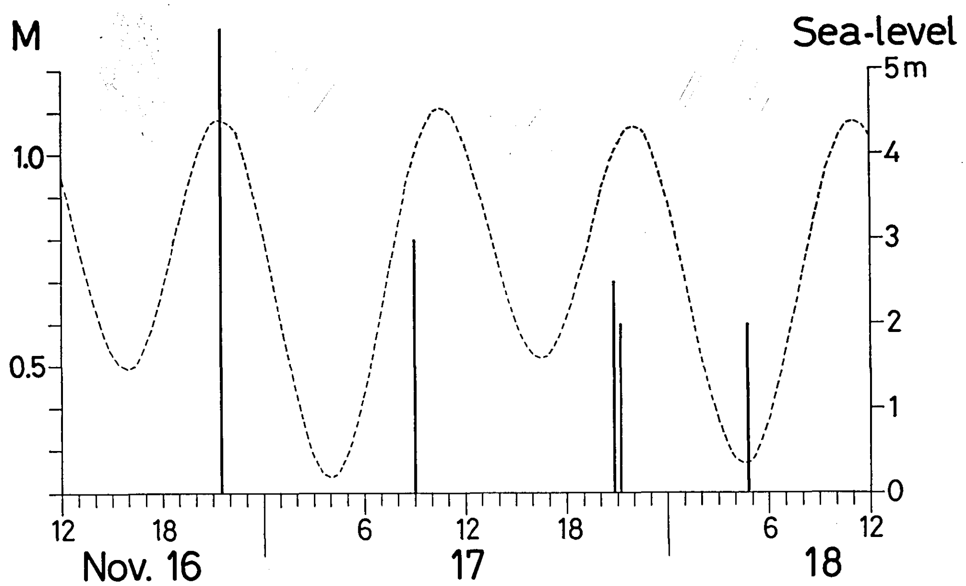

Fig. 5. Activity under the Shimabara Bay on November 16-18, 1978. The main shock and aftershocks suggested a semi-diurnal cycle approximately corresponding to the high tide of the Bay. The dotted curve represents the theoretical sea-level at Shimabara (OHTSU, 1977).

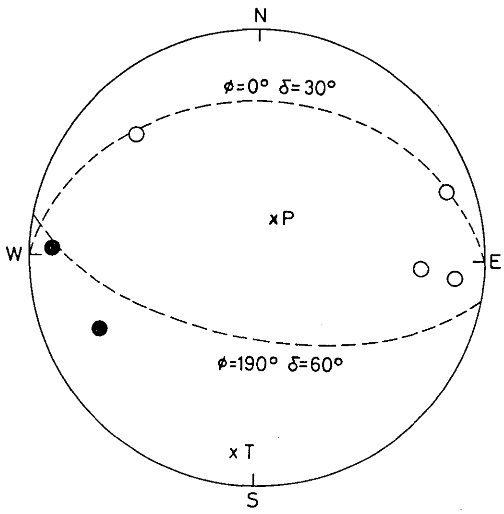

Fig. 6. A possible focal mechanism (broken curves) of the main shock of the Shimabara Bay earthquake on November 16, 1978. Open and solid circles represent dilatation and compression of P wave first motions, respectively. Plot is an equal area projection on the lower focal hemisphere.

and were located close to it. The main and aftershocks showed a semi-diurnal cycle approximately corresponding to high tide of the Bay, except the last smallest one (Fig. 5).

P wave first motions of the main shock is projected on the lower focal hemisphere in Fig. 6. Although it was difficult to obtain a unique solution, a focal mechanism of a normal fault type was able to be taken as in Fig. 6, referring those of the adjacent areas (YAMASHINA and MURAI, 1975; YAMASHINA and MITSUNAMI, 1977). The data of aftershocks were, roughly speaking, also able to be explained by a normal faulting. If this was the case, the earthquake-generating stress should have been increased in the focal region by the ocean load at high tide. The tidal range in the Shimabara Bay is known to be large, extending over 5 m. The maximum double amplitudes ranged about 2.5–4.5 m in this month corresponding to the neap and the flood tide, respectively (OHTSU, 1977). The observation period corresponded to just the flood of tide; the main shock occurred on the next day of the full of the moon. It is possible that this tidal fluctuation may trigger earthquakes if the tectonic stress is near a critical state. The fluctuation in differential stress was estimated to attain about 300 mb at the sea bottom, assuming a Poisson's ratio of 0.25. This effect, however, if indeed significant, would not be always necessary, since the last recorded aftershock occurred at low tide.

(b) Activity near Ueki

During the survey, a microearthquake swarm occurred near Ueki, north of Kumamoto. This may still be the aftershock activity of the $M=5.2$ earthquake which struck the area in the previous year. The sequence of this swarm was quite interesting in its cyclic activity (Fig. 7). Though only four shocks of the swarm were located, many other swarm events were recognized by a similarity of P arrivals, S–P times and wave forms of both the East and Northwest stations.

During about 80 hours, including the period when the southwest station was out of operation, there were three cycles of activity with a period of about 20 hours. It composed of active and inactive periods of about 8 and 12 hours, respectively. As shown in Fig. 7, the activity started with minor shocks. The magnitude of the shocks became larger. And finally the activity terminated suddenly by the occurrence of the largest shock. Aftershocks of this major event were scarcely observed. The magnitudes of the largest events in respective cycles were 1.3, 1.5 and 0.6 in succession.

The progress of this seismic activity may suggest a hypothesis on

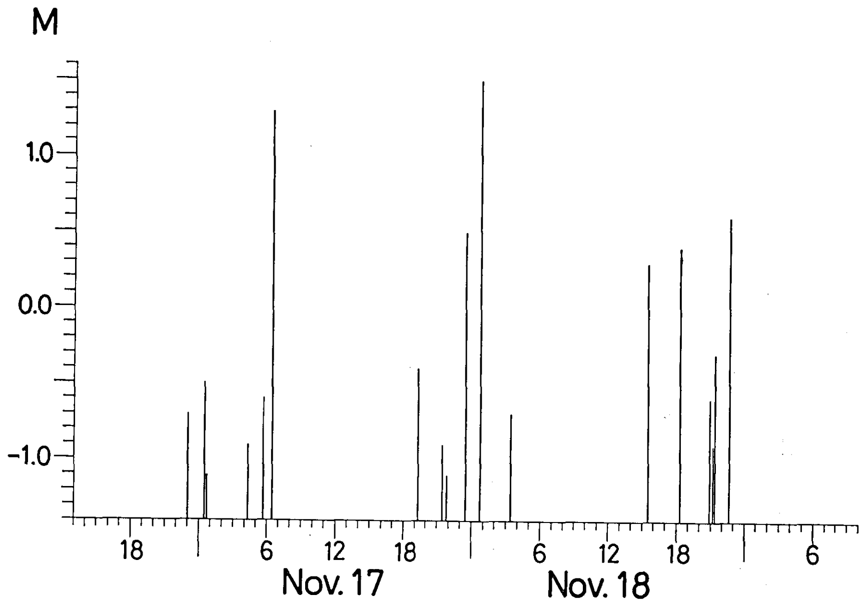

Fig. 7. Sequence of the earthquake swarm near Ueki, about 15 km north of Kumamoto, observed during November 16-19, 1978.

earthquake prediction that, when the magnitude increases, a still larger earthquake may occur with a higher probability than those otherwise. The end of the activity may be recognized by the following quiescent period. Although earthquakes with maximum magnitude of about 3 occurred in this area on November 21-22 (MITSUNAMI, unpublished), two days after the present survey, the relation to the previous swarm activity was not known.

4. Conclusions

The results of a temporary microearthquake observation near Kumamoto during November 15-19, 1978, are summarized as follows.

(1) 30 earthquakes were located during 45 hours of observation on November 16-18, when the tripartite network were all in operation. Most of them were determined to be shallower than 15 km, if they were not far from the network. The maximum magnitude shown in Fig. 3 during this period was estimated here as 2.0.

(2) An earthquake with magnitude of 1.3 occurred under the Shimabara Bay and was followed by four aftershocks. They showed a semidiurnal cycle approximately corresponding to high tide of the Bay, except the last smallest one. This may suggest that the increase of the crustal

Table 2. List of seismic data. F-P and A represent signal duration and maximum velocity amplitude of vertical component, respectively.

Code	Date			h	m	P sec	S-P sec	F-P sec	A µkine	Comments
F	11	16	− P	14	09	17.87		14	18	
F	11	16	− P	14	26	54.49		30	6	
F	11	16	+ P	15	57	44.05		6	7	
F	11	16	− P	16	32	54.91	(5.)	17	5	
F	11	16	+ P	16	52	23.48		16	64	
U	11	16	− P	16	52	27.11				
F	11	16	− P	17	01	51.53		63	26	
F	11	16	− P	18	41	47.92		14	5	
I	11	16	+eP	18	41	46.25	2.10			
U	11	16	−iP	18	41	45.06	(1.35)			
F	11	16	+ P	19	45	55.28		12	39	
F	11	16	+ P	20	21	00.49		7	22	
F	11	16	+eP	21	00	18.93		23	43	
F	11	16	+eP	21	02	21.96	(1.33)	17	19	
I	11	16	−eP	21	02	26.94				
F	11	16	+iP	21	31	44.17		43	150	Shimabara
I	11	16	+iP	21	31	41.18	1.89			Bay
U	11	16	−iP	21	31	41.16				
F	11	16	+ P	22	22	11.50	(2.)	12	3	
F	11	16	+iP	23	01	01.80		9	5	Near Ueki
I	11	16	+ P	23	01	00.52	2.13			

Code	Date			h	m	P sec	S-P sec	F-P sec	A µkine	Comments
F	11	17	+eP	00	29	55.20		10	1	
F	11	17	− P	00	35	25.06	(2.05)	11	5	Near Ueki
I	11	17	+ P	00	35	23.66	1.96			
F	11	17	+ P	00	36	23.97	(2.02)	7	1	Near Ueki
I	11	17	−eP	00	36	22.48				
F	11	17	+iP	00	51	31.33	(2.)	8	2	
F	11	17	+ P	02	15	14.12		12	3	
I	11	17	−eP	02	15	12.00				
F	11	17	−eP	02	32	45.70		85	65	Western
I	11	17	− P	02	32	47.65	22.42			Setonaikai
U	11	17	+eP	02	32	48.85				(M=3.1)
F	11	17	+ P	03	54	31.28	(1.6)	5	3	
F	11	17	− P	04	19	32.20		8	3	Near Ueki
I	11	17	− P	04	19	31.33	2.13			
F	11	17	+eP	04	26	18.70	(11.)	30	17	
I	11	17	+eP	04	26	15.82	9.81			
U	11	17	+ P	04	26	18.54				
F	11	17	− P	04	57	28.45		30	12	
I	11	17	−eP	04	57	25.86	6.46			
U	11	17	+ P	04	57	24.75				
F	11	17	+ P	05	14	46.15		20	8	
I	11	17	+ P	05	14	44.36	2.19			
U	11	17	−iP	05	14	43.07	(1.42)			

Table 2. (continued).

Code	Date			h	m	P sec	S-P sec	F-P sec	A μkine	Comments
F	11	17	+ iP	05	17	22.18		12	5	
F	11	17	+eP	05	24	00.60		28	6	
I	11	17	+eP	05	23	57.43	5.32			
U	11	17	+eP	05	23	58.80				
F	11	17	+ iP	05	39	55.22	(1.99)	10	3	Near Ueki
I	11	17	+ iP	05	39	53.95	2.00			
F	11	17	+ iP	06	27	28.43		42	150	Near Ueki
I	11	17	− iP	06	27	27.45	2.30			
U	11	17	− P	06	27	29.62				
F	11	17	−eP	07	17	56.23		60	64	
I	11	17	− P	07	17	57.00	6.17			
U	11	17	+eP	07	17	58.84				
F	11	17	+eP	07	45	15.51		40	9	
F	11	17	− P	08	36	12.98		13	3	
F	11	17	+ P	09	02	55.99		30	25	Shimabara Bay
I	11	17	− P	09	02	53.10	1.96			
U	11	17	− iP	09	02	52.98				
F	11	17	− P	10	21	37.15	(2.)	6	4	
F	11	17	+ P	11	40	54.11		10	8	
F	11	17	− P	13	42	59.53		20	10	
I	11	17	− P	13	43	01.35	15.54			

Code	Date			h	m	P sec	S-P sec	F-P sec	A μkine	Comments
F	11	17	+ iP	13	48	36.11		7	5	Blast?
I	11	17	+ P	13	48	34.48	1.54			
U	11	17	+eP	13	48	33.20				
F	11	17	+ iP	13	56	03.78		10	10	
U	11	17	+ P	13	56	02.67				
F	11	17	−eP	14	29	47.75		19	6	
F	11	17	+ iP	17	09	10.02		12	19	
U	11	17	− P	17	09	10.35				
F	11	17	− iP	17	17	39.31		19	13	
I	11	17	+ P	17	17	37.17	2.65			
U	11	17	−eP	17	17	38.17				
F	11	17	− iP	17	42	59.30		75	>180	
I	11	17	+ iP	17	43	01.48	4.82			
U	11	17	− iP	17	42	59.60				
F	11	17	− P	18	14	29.57		60	10	
I	11	17	+eP	18	14	30.29	3.76			
U	11	17	− iP	18	14	28.72				
F	11	17	− iP	18	37	20.19		16	8	
I	11	17	+eP	18	37	16.90	1.64			
U	11	17	−eP	18	37	19.17				
F	11	17	− P	19	03	36.80		13	4	
F	11	17	+ iP	19	23	57.39		12	9	Near Ueki
I	11	17	+eP	19	23	56.20	2.06			
U	11	17	−eP	19	23	58.45	(3.65)			

Table 2. (continued).

Code	Date			h	m	P sec	S-P sec	F-P sec	A μkine	Comments
F	11	17	+eP	19	31	02.98	(3.)	17	3	
I	11	17	− P	19	31	00.54	4.51			
F	11	17	−eP	20	22	48.26		32	20	
I	11	17	−eP	20	22	46.36	3.97			
U	11	17	−eP	20	22	48.83				
F	11	17	+ P	20	54	30.11		27	18	Shimabara Bay
I	11	17	− P	20	54	27.22	2.05			
U	11	17	− iP	20	54	27.10				
F	11	17	− P	21	05	33.86		22	7	
U	11	17	+eP	21	05	33.37				
F	11	17	+ iP	21	18	35.83		25	19	Shimabara Bay
I	11	17	− P	21	18	32.90	2.05			
U	11	17	− P	21	18	32.81	(1.94)			
F	11	17	+ P	21	33	26.11		8	3	Near Ueki
I	11	17	−eP	21	33	25.44	2.36			
F	11	17	+ P	21	47	36.49		7	4	Near Ueki
I	11	17	P	21	47	36.06	2.18			
F	11	17	+ iP	23	27	53.64		23	35	Near Ueki
I	11	17	+ P	23	27	52.37	2.12			
U	11	17	− P	23	27	54.80				
F	11	17	+eP	23	37	01.03		12	1	
F	11	18	+ iP	00	26	22.22	(2.5)	28	140	
I	11	18	+eP	00	26	25.34	4.93			
U	11	18	+eP	00	26	24.25	(4.33)			

Code	Date			h	m	P sec	S-P sec	F-P sec	A μkine	Comments
F	11	18	−eP	01	03	52.82		12	1	
I	11	18	+eP	01	03	50.45				
F	11	18	−eP	01	16	36.32		45	5	
F	11	18	+eP	01	24	45.93		12	3	
I	11	18	+eP	01	24	47.84				
F	11	18	+ iP	01	46	49.70		50	>180	Near Ueki
I	11	18	− iP	01	46	49.09	2.26			
U	11	18	iP	01	46	51.25				
F	11	18	+eP	02	13	29.29		25	4	
I	11	18	+eP	02	13	27.50	12.35			
F	11	18	−eP	02	20	56.55		23	3	
I	11	18	+eP	02	20	54.67	12.00			
F	11	18	+ iP	02	35	32.46		25	31	
I	11	18	−eP	02	35	34.11				
U	11	18	−eP	02	35	33.33				
F	11	18	+ iP	02	58	45.35		16	6	
I	11	18	+ P	02	58	43.74	2.26			
U	11	18	+ iP	02	58	41.77	(1.07)			
F	11	18	− P	03	24	38.77	(2.)	9	2	Near Ueki
I	11	18	+eP	03	24	37.24	2.00			
F	11	18	+ iP	03	53	30.23		40	>180	
I	11	18	+eP	03	53	33.23	4.64			
U	11	18	−eP	03	53	34.50				

Table 2. (continued).

Code	Date			h	m	P sec	S-P sec	F-P sec	A μkine	Comments
F	11	18	+eP	03	55	18.78		9	1	
I	11	18	− P	03	55	15.54				
F	11	18	− P	04	20	32.50		30	6	
I	11	18	− P	04	20	36.61				
F	11	18	+ iP	04	47	43.10		15	13	
I	11	18	−eP	04	47	44.08	3.60			
F	11	18	−eP	04	48	51.62		25	12	Shimabara Bay
I	11	18	− P	04	48	48.74	1.98			
U	11	18	− iP	04	48	48.68				
F	11	18	+eP	04	58	40.74		22	14	
I	11	18	+ P	04	58	38.25	4.09			
U	11	18	−eP	04	58	40.45				
F	11	18	−eP	05	17	11.72		15	3	
I	11	18	P	05	17	08.54				
F	11	18	+eP	06	04	49.23		60	140	
I	11	18	−eP	06	04	52.07	17.95			
U	11	18	−eP	06	04	51.17				
F	11	18	− iP	06	36	45.83		7	8	
F	11	18	+eP	06	45	32.84	(6.)	22	4	
I	11	18	− P	06	45	29.60	4.45			
U	11	18	− P	06	45	31.20				
F	11	18	− P	06	55	21.47		45	>180	
I	11	18	−eP	06	55	25.11	9.79			
U	11	18	+eP	06	55	25.17				

Code	Date			h	m	P sec	S-P sec	F-P sec	A μkine	Comments
F	11	18	− iP	06	57	54.72		12	21	
F	11	18	+ iP	07	53	10.93		29	130	
I	11	18	+ P	07	53	14.10	4.02			
U	11	18	+eP	07	53	14.26				
F	11	18	+ iP	13	02	15.30		12	10	
F	11	18	+ P	13	58	22.07		28	3	
F	11	18	− P	14	16	39.27	(4.)	14	4	
F	11	18	+ P	14	43	33.07		19	6	
F	11	18	− P	15	32	43.89		25	11	
F	11	18	+ P	15	34	53.29		20	16	Near Ueki
I	11	18	− P	15	34	51.95	1.84			
F	11	18	+ iP	15	41	20.37		49	>180	
I	11	18	+eP	15	41	22.04	3.68			
F	11	18	+ P	16	27	40.44		22	57	
F	11	18	− P	16	28	58.04	(3.)	15	16	
I	11	18	+ P	16	28	56.17	1.38			
F	11	18	− iP	17	00	55.39	(4.5)	14	11	
F	11	18	+ P	17	04	29.57		13	12	
F	11	18	+ iP	18	18	52.44		22	48	Near Ueki
I	11	18	+ iP	18	18	51.27	2.07			

Table 2 (continued).

Code	Date			h	m	P sec	S-P sec	F-P sec	A μkine	Comments
F	11	18	−eP	18	25	11.04		15	2	
F	11	18	+eP	19	00	25.97		38	11	
I	11	18	−eP	19	00	29.06				
F	11	18	+iP	20	29	47.99		20	19	
I	11	18	P	20	29	45.72	4.08			
F	11	18	+iP	20	36	18.27		15	16	
F	11	18	+ P	20	58	45.44	(2.)	10	7	Near Ueki
I	11	18	+ P	20	58	44.15	1.90			
F	11	18	+ P	21	16	50.70	(2.)	8	3	Near Ueki
I	11	18	+ P	21	16	49.27	2.30			
F	11	18	+ P	21	17	11.44		13	11	Near Ueki
I	11	18	+ P	21	17	10.05	2.07			
F	11	18	− P	21	31	47.34		9	6	
I	11	18	− P	21	31	47.50	2.13			
F	11	18	−iP	22	41	34.43		26	71	Near Ueki
I	11	18	iP	22	41	33.03	1.79			
F	11	18	−iP	23	25	49.88	(2.07)	10	8	
F	11	18	+ P	23	44	53.09		15	13	
F	11	19	+ P	00	39	59.54		13	2	
F	11	19	+eP	00	57	39.86	(1.5)	10	3	
F	11	19	+eP	02	21	12.59	(8.)	21	6	
I	11	19	+eP	02	21	09.80				
F	11	19	+eP	02	21	44.68		11	4	
I	11	19	− P	02	21	44.00				
F	11	19	+ P	02	34	37.31		20	9	
I	11	19	+ P	02	34	35.17	4.4			
F	11	19	+ P	04	03	35.25		11	1	
F	11	19	+iP	04	09	49.25		24	48	
I	11	19	+ P	04	09	50.92	3.80			
F	11	19	−iP	04	53	29.08		16	27	
F	11	19	+eP	06	41	56.24		14	3	
I	11	19	+ P	06	41	53.04				
F	11	19	+eP	09	29	58.99		18	5	

stress caused by the ocean tide can trigger earthquakes when it is near a critical state. A plausible solution of a normal fault type of the P wave first motions supports this idea.

(3) A swarm activity was observed near Ueki, where the M=5.2 event occurred in 1977. The activity was periodic with a cycle of about 20 hours. Active and inactive periods repeated alternately over again with durations of about 8 and 12 hours, respectively. Each cycle was characterized by occurrence of minor shocks, increase in magnitude, and finally the outbreak of the largest shock followed by a quiescent period. The largest magnitudes in respective cycles were 1.3, 1.5 and 0.6 in succession.

(4) Seismic activity relating to the adjacent major faults such as

Table 3. List of earthquakes shown in Fig. 3.

	Date		Origin h	m	Time sec	Long. (E)	Lat. (N)	Depth (km)	Mag.	Comments
1	11	16	18	41	43.4	130°34.5′	32°41.8′	10	−0.2	
2			21	31	38.6	130°29.3′	32°45.8′	6	1.3	Shimabara Bay
3	11	17	05	14	41.4	130°33.5′	32°41.5′	9	0.3	
4			05	23	50.2	130°17.3′	33°01.3′	20	0.7	
5			06	27	24.3	130°43.1′	32°55.2′	12	1.3	Near Ueki
6			07	17	48.6	130°57.6′	33°03.1′	30	1.7	
7			09	02	50.4	130°29.4′	32°45.5′	8	0.8	Shimabara Bay
8			13	48	32.4	130°36.4′	32°42.5′	3	−1.1	Blast?
9			17	17	33.6	130°33.6′	32°50.4′	21	0.2	
10			17	42	54.9	130°49.5′?	32°31.7′?	0?	2.0	
11			18	14	25.2	130°42.9′	32°35.4′	15	1.7	
12			18	37	14.7	130°32.4′	32°54.9′	0	0.0	
13			19	23	53.4	130°42.4′	32°54.9′	10	−0.4	Near Ueki
14			20	22	40.9	130°37.4′	33°05.2′	13	0.9	
15			20	54	24.4	130°29.1′	32°45.5′	8	0.7	Shimabara Bay
16			21	18	30.1	130°28.8′	32°45.7′	8	0.6	Shimabara Bay
17			23	27	49.5	130°42.5′	32°56.3′	7	0.5	Near Ueki
18	11	18	00	26	18.6	130°55.9′?	32°35.6′?	0?	0.7	
19			01	46	46.0	130°44.6′	32°54.8′	10	1.5	Near Ueki
20			02	58	40.7	130°33.7′	32°40.1′	6	0.0	
21			03	53	26.9	131°03.3′?	32°49.5′?	0?	1.2	
22			04	48	46.0	130°29.5′	32°45.7′	8	0.6	Shimabara Bay
23			04	58	32.7	130°31.2′	33°03.9′	16	0.4	
24			06	45	23.5	130°20.8′	33°00.9′	13	0.4	
25			07	53	08.6	130°56.3′	32°42.9′	9	0.8	

the Futagawa-Hinagu fault system and the Usuki-Yatsushiro Tectonic Line was not apparent during this period.

(5) Underneath the urban area of Kumamoto City, which the present network covered, there were no observable shocks during this period. Both (4) and (5) may have, of course, resulted from the short term of observation.

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27. 熊本付近で観測された2つの周期的微小地震活動

—1978年11月の臨時観測成果—

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1978年11月15-19日，熊本付近で微小地震の3点観測を行なった．熊本市街直下の地震や，周辺の顕著な活断層系に直接対応するような地震は，この期間には観測されなかった．しかし，島原湾で起きた M=1.3 の地震と，植木付近で起きた群発的活動（最大の M=1.5）は，興味深い活動であった．島原湾の地震の本震と余震（4回のうち1回を除く）は，島原湾の満潮時に発生した．P 波初動を調べると，正断層型のメカニズム解をもつ可能性がある．もしそうなら，海水の荷重のために満潮時に起震応力が増大し，この作用によって地震が誘発されたと考えられるかもしれない．一方，植木付近の活動は，およそ20時間前後の周期性が見られた．各サイクルの活動は特徴的で，まずごく小さな地震が起こり始め，マグニチュードがしだいに大きくなり，各サイクルの中の最大の地震が起きたあとは，約12時間ほどの静穏期にはいるという経過を3回くり返した．