ANALYSIS OF SEISMIC EVENTS AS RECORDED ON BOTH WIDE BAND LONG PERIOD AND STANDARD VELA LONG PERIOD SEISMOGRAPH SYSTEMS

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SEISMIC DATA LABORATORY

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ABSTRACT

Analysis of seismic signals recorded on both the standard long period and the wide band long period seismograph systems at TFO revealed that these systems yield equivalent information concerning long period energy in the signals. The Rayleigh wave energy at periods greater than sixty seconds was determined to originate almost entirely from events with epicenters near oceanic trenches or oceanic ridges.

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INTRODUCTION

Since 25 September 1969, two wide band long period vertical seismograph systems (LZX and LZY) have been operating at TFO. These systems have an amplitude response peaked at approximately 40 seconds and have a wider pass band than the standard long period LRSM or VELA instruments (Figure 1). The wide band response is achieved with a Geotech 7505A vertical seismometer coupled to a photo tube amplifier with a six second notch filter (Figure 2) and a galvanometer. The free period of the seismometer is 26 seconds and that of the galvanometer is 108 seconds. The response of these wide band systems is very similar to a long period broad-band seismograph system developed at Lamont Geological Observatory (Pomeroy et al, 1969; and Molnar et al, 1969). The two wide band seismograph systems at TFO are located at the same site as a standard VELA vertical seismometer (LZ1).

Seismic events recorded by this standard seismograph system and the wide band (LZX) system were analyzed to compare the performance of the two recording systems and to see if the wide band systems could detect more long period energy then the standard systems. This would be of great importance for discrimination purposes. The analysis techniques used included period measurements from film records, analog low pass filtering, and digital computation of spectra.

LONGEST PERIODS OBSERVABLE IN RAYLEIGH WAVE SIGNALS

Film recordings from the standard (LZ1) and wide band (LZX) seismograph systems at TFO were used to obtain measurements of the longest period observable in the first five minutes of Rayleigh wave signals from seismic events. Events were selected for measurement from film recordings made during the time period 1 October 1969 to 1 March 1970. Only Rayleigh waves with a good signal to noise ratio and free of any obvious interference from other signals were measured. Also very few measurements were made of events having a longest Rayleigh wave period of less than 30 seconds.

The source parameters of the events measured were taken from the USC&GS epicenter lists and are given in Table I, together with the longest periods measured in the Rayleigh wave signals as observed from both the standard and the wide band recordings. The longest periods for all events are also presented in Figure 3, and the epicenters are shown in Figure 4 with the symbol for each epicenter denoting the period range in which the wide band measurement falls.

It can be seen that, for each event, the difference between the periods measured from the standard and the wide band recordings is usually less than five seconds (Figure 3). This indicates that although at the long periods the amplitude of the signal as recorded by the wide-band system may be larger than that for the signal as recorded by the standard system, the period measurement can still be made from recordings of the standard long period seismograph system. As examples of the standard and wide band long period recordings at TFO, signals from some of the events listed in Table I are shown in Figures 5 through 9.

The distribution of epicenters shown in Figure 4 indicates that events producing Rayleigh wave energy at periods equal to or greater than 60 seconds (within the first five minutes of the Rayleigh signal) are for the most part located near oceanic trenches and along oceanic ridges. One event with a measured period greater than 60 seconds is located in India. However, with a data set of 150 events, it is not possible to conclude that events producing energy at long periods will always follow this same epicenter pattern.

In addition to the measurements made for the events listed in Table I, Rayleigh wave signals for all events given in the USC&GS PDE cards for the time period 22 February 1970 through 28 February 1970 were measured from the standard and wide band film recordings. It was determined from this analysis that all events in this time period which could be seen in the wide band recordings could also be seen in the standard recordings; the difference in the longest period measured from both recordings was in all cases less than five seconds.

FREQUENCY CONTENT OF SIGNALS RECORDED BY WIDE BAND AND STANDARD SEISMOGRAPHS

The similarity in the frequency content of seismic signals recorded by the wide band LZX system and the standard VELA LZ1 system was investigated by low pass filtering using an analog processor. The signals filtered were generated by an earthquake in the Central Pacific Ocean on 4 November 1969; other source information for the earthquake is given in Table II. The filters used were 40-, 75-, and 100-second low pass filters. The relative response of the 40 second low pass filter is shown in Figure 10.

The filtered signals are presented in Figure 11. These signals indicate that the same frequencies are present in the wide band and standard recordings with slight amplitude differences due to the difference in the response of the two seismograph systems.

The similarity in the spectra of Rayleigh wave signals recorded by the wide band and the standard VELA systems can also be seen in Figures 12 through 15 for the events listed in Table II. The differences at low frequency reflect the different responses seen in Figure 1. The power spectra of the signals were computed using a group velocity window of approximately 3 to 4 km/sec with the one exception of signals from the earthquake in the Philippines for which a velocity window of 3.5 to 4 km/sec was used.

The noise spectra were computed using a segment consisting of 1024 seconds of each time trace. The noise sample for each event terminated before the signal arrival time.

For each event listed in Table II, signal to noise ratios

(S/N) were computed at selected periods from 20 to 75 seconds. The wide band signal and noise power spectra given in Figures 12 through 15 were used to calculate the S/N values which, as can be seen from Table III, are not less than 2.5 for any period. Therefore reliable estimates of the signal spectra were obtained for the events processed even at periods as long as 75 seconds.

Signal to noise ratios were also calculated for the standard system and are given in Table III, together with the ratio of the signal to noise ratio of the wide band to that of the standard instrument. Ideally, for earth noise, this ratio would be close to 1.0. This is apparently the case below 33 seconds period. Above 33 seconds the ratios are more variable but still average close to 1.0. This suggests that the system noise is greater than the earth noise in this band. Since the system noise can be different on the different channels at any particular time, then we can expect ratios different from 1.0 for any given realization even though the average system noise is identical. These results suggests that the earth noise and system noise are identical on the two systems except to the extent that they are shaped by the system response.

CONCLUSIONS

The longest period observed on earthquake records detected by either the standard or wide-band long period seismometers has been found to be nearly identical for a suite of earthquakes. This is what would be expected if the signal was above the system noise, and if noise outside the frequency band of the longest period did not obscure the information in that band. Evidently neither of these possibilities is a serious problem in practice.

Events producing Rayleigh waves with periods greater than 60 seconds seem to be associated almost entirely with oceanic trenches or ridges.

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We wish to thank P.E. DeFries, J.E. Dunavant, Jr., and D.M. Clark for their valuable assistance in the analysis of the long period data. We are grateful to Lt. J. Fergus of the Vela Seismological Center and to M. Gudzin for supplying information on the wide band long period seismograph system at TFO.

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Pomeroy, P.W., Hade, G., Savino, J., and Chander, R., 1969, Preliminary results from high-gain wide-band long-period electromagnetic seismograph systems: J. Geophys. Res., v. 74, p. 3295-3298.

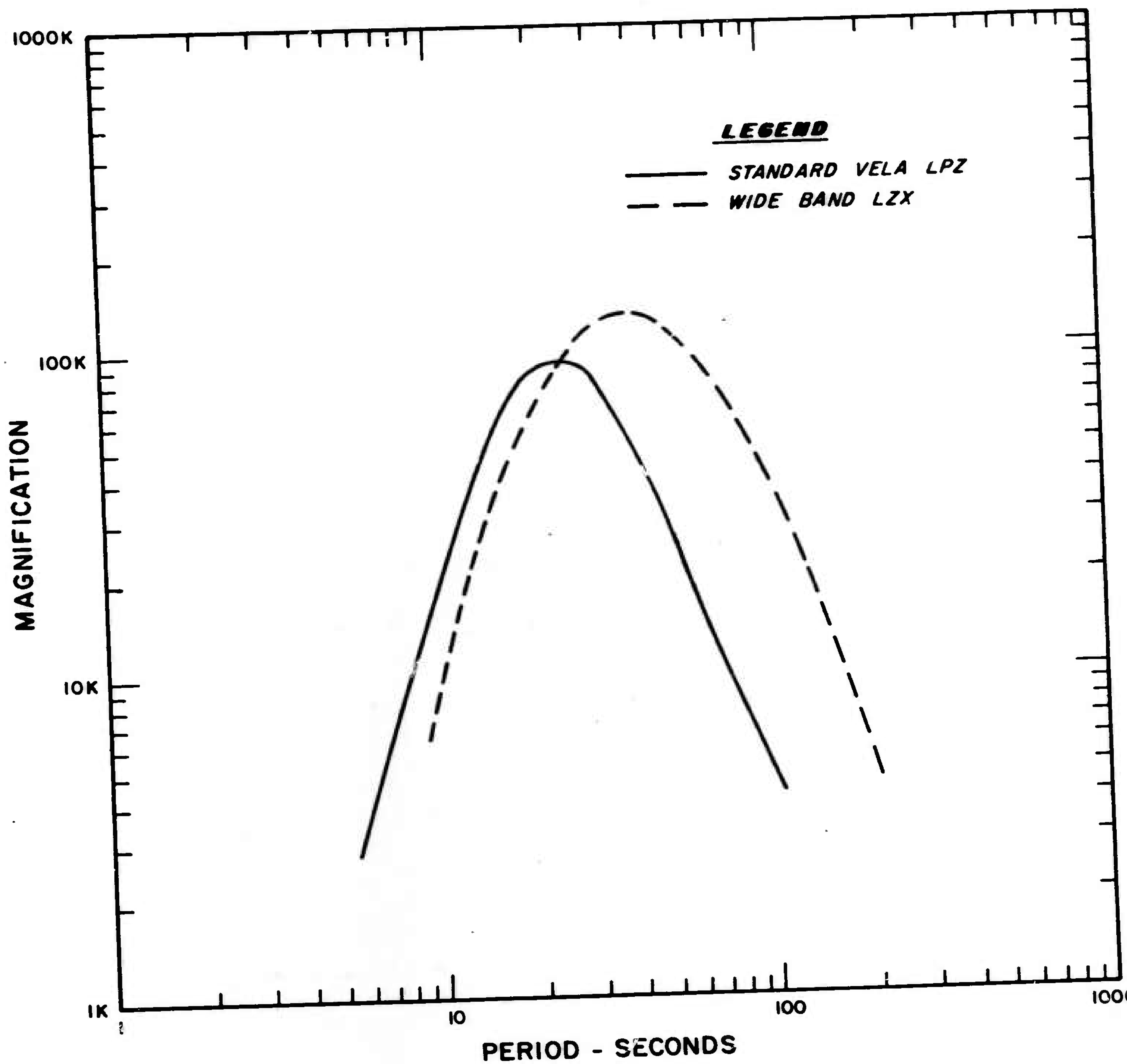


Figure 1. System response of standard Vela long period and of wide band long period seismographs.

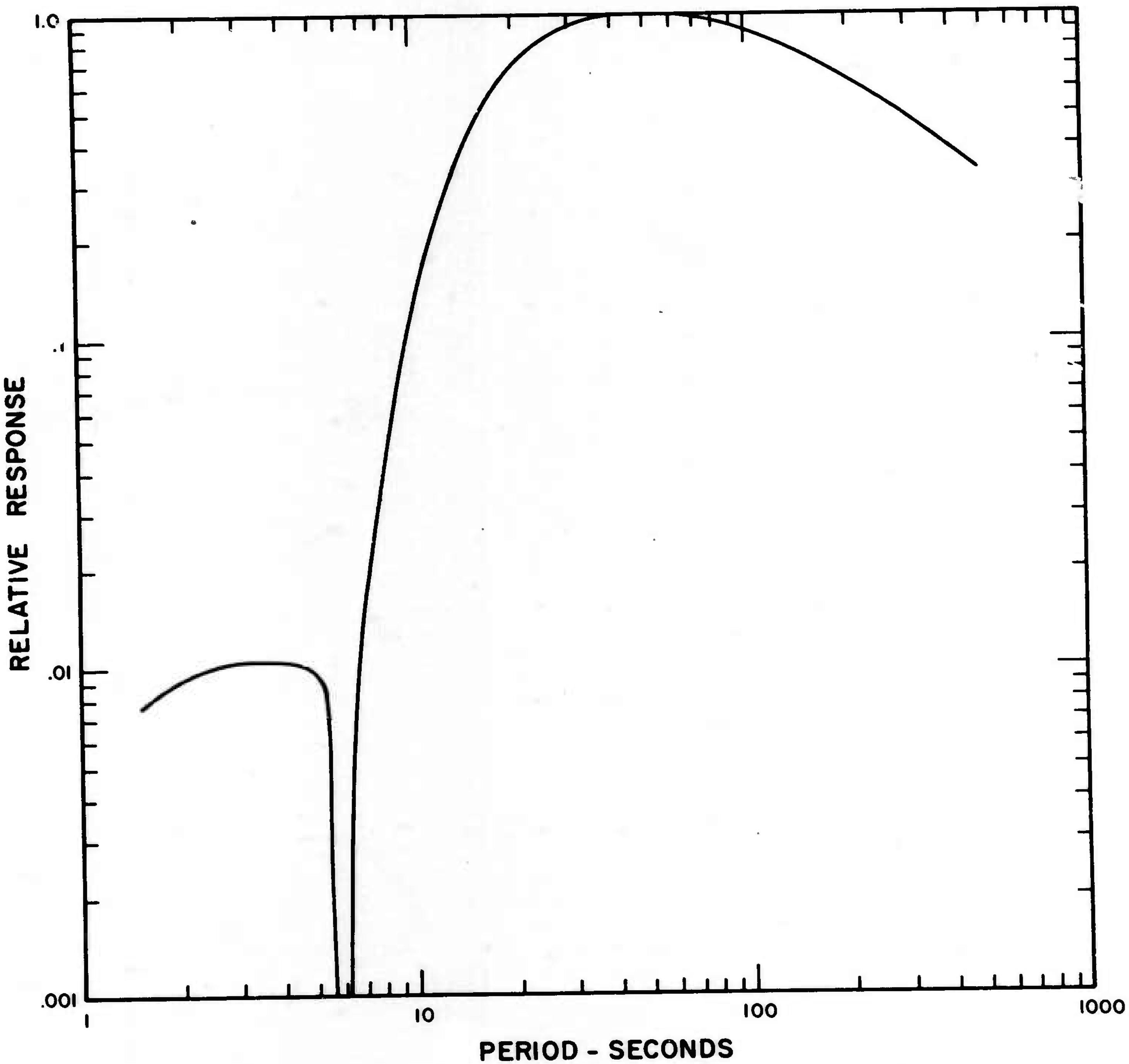


Figure 2. Relative response of the six second notch filter in the wide band seismograph system.

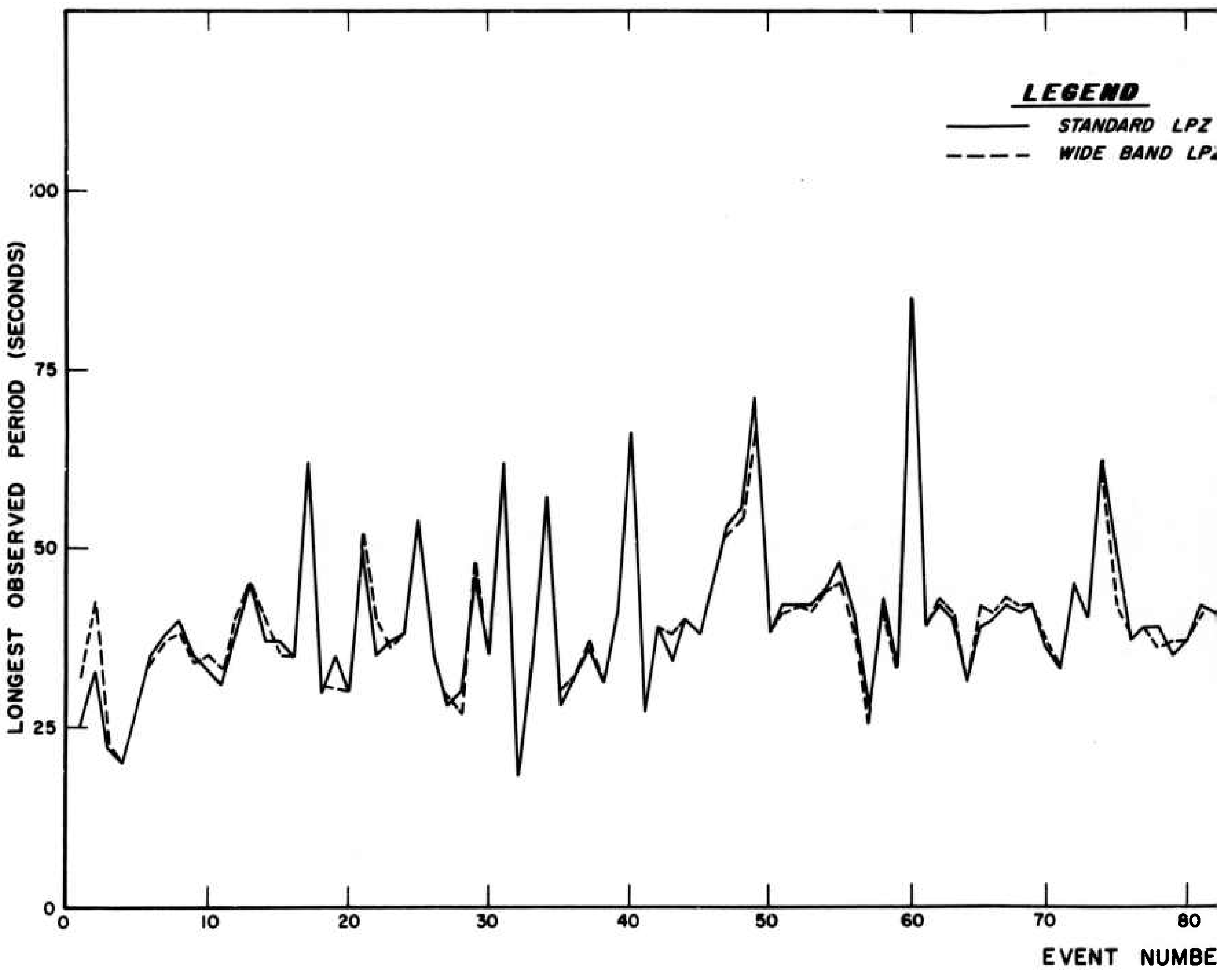
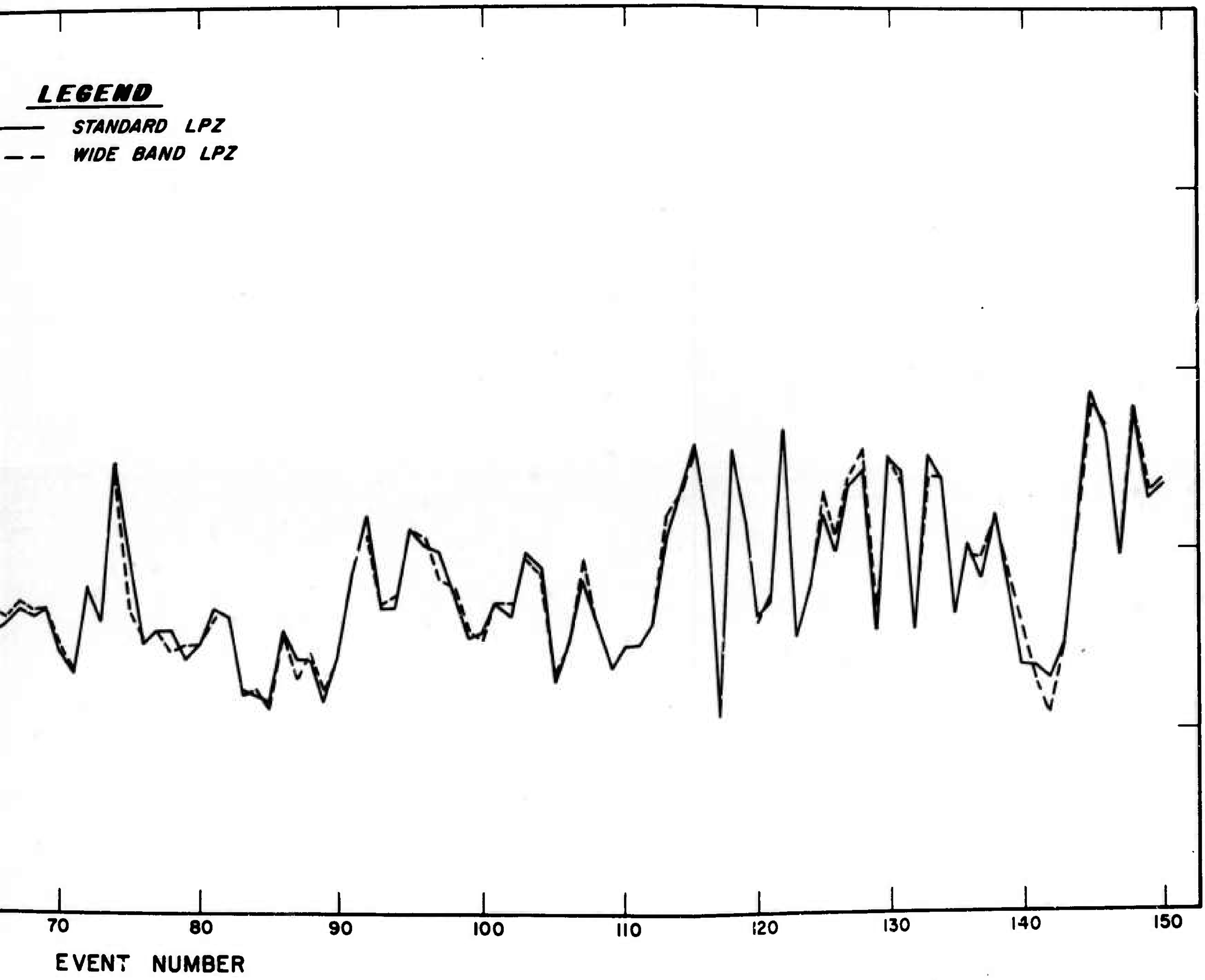


Figure 3. Longest observed periods in Rayle
signals recorded by wide band and
Vela long period seismograph syst



observed periods in Rayleigh wave
recorded by wide band and standard
ng period seismograph systems.

B

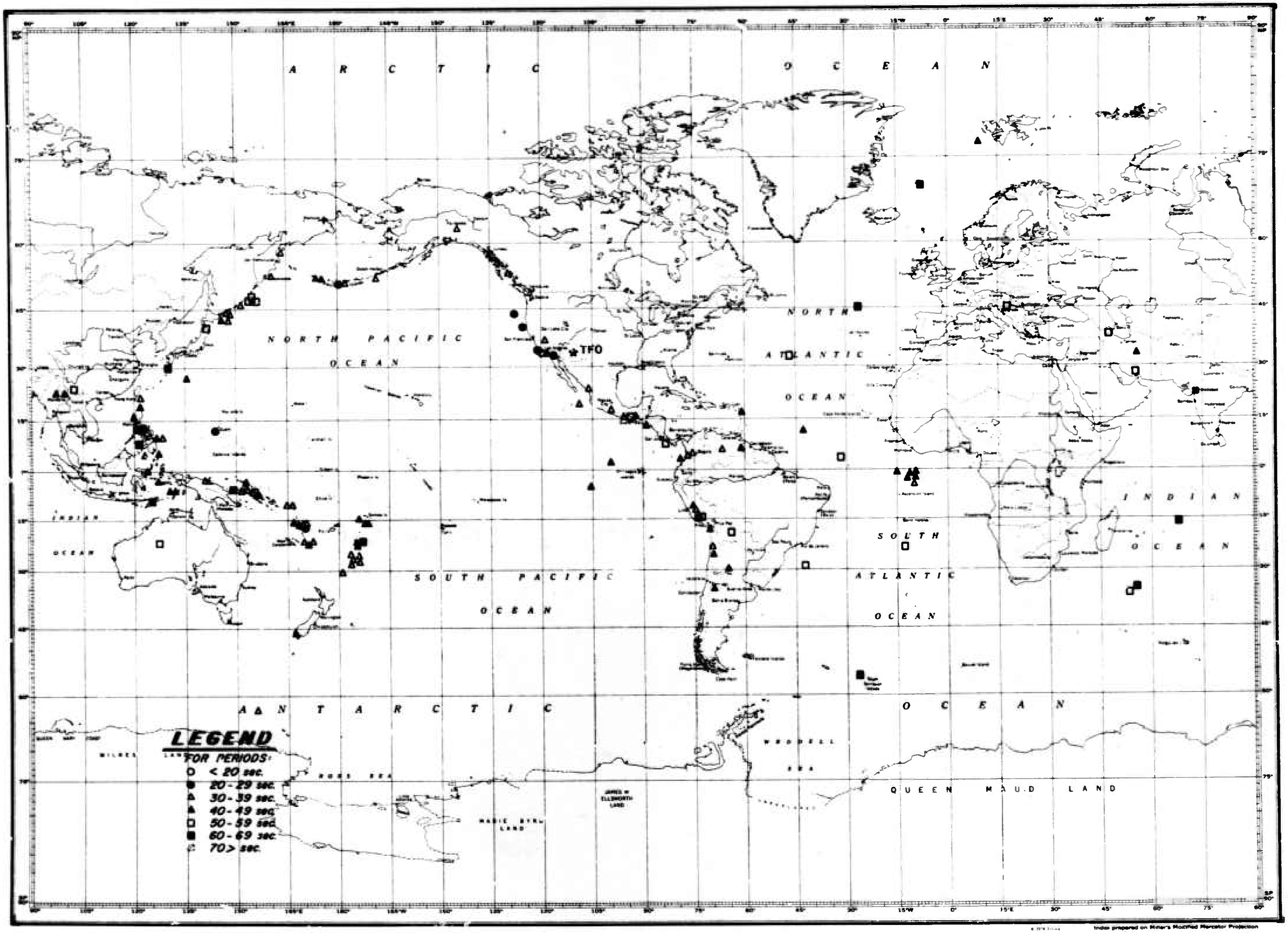


Figure 4. Epicenters and period ranges of events used in film analysis of Rayleigh waves.

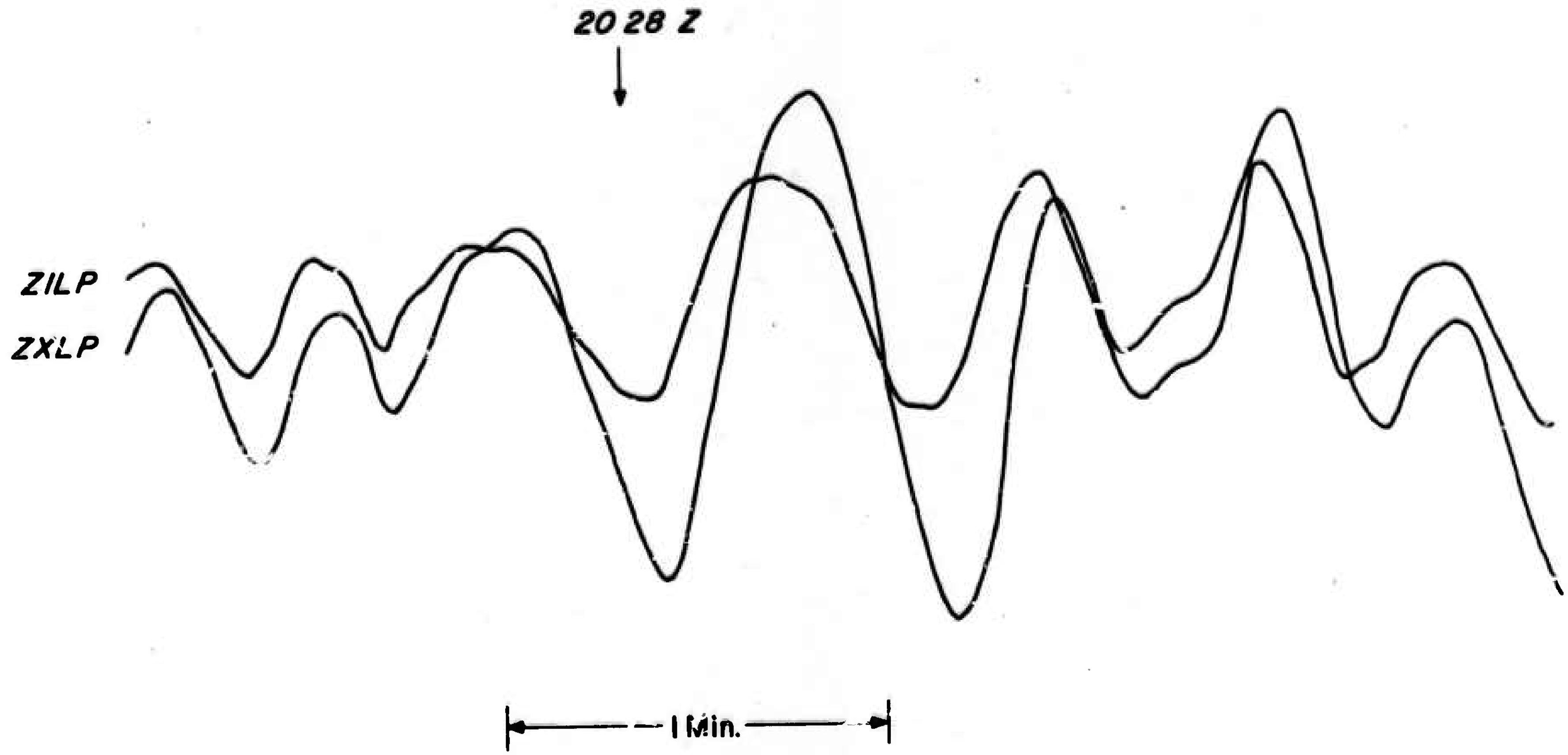


Figure 5. Standard Vela and wide band long period recordings of an event in the Banda Sea on 10 February 1970 at 19:34:05.7Z.

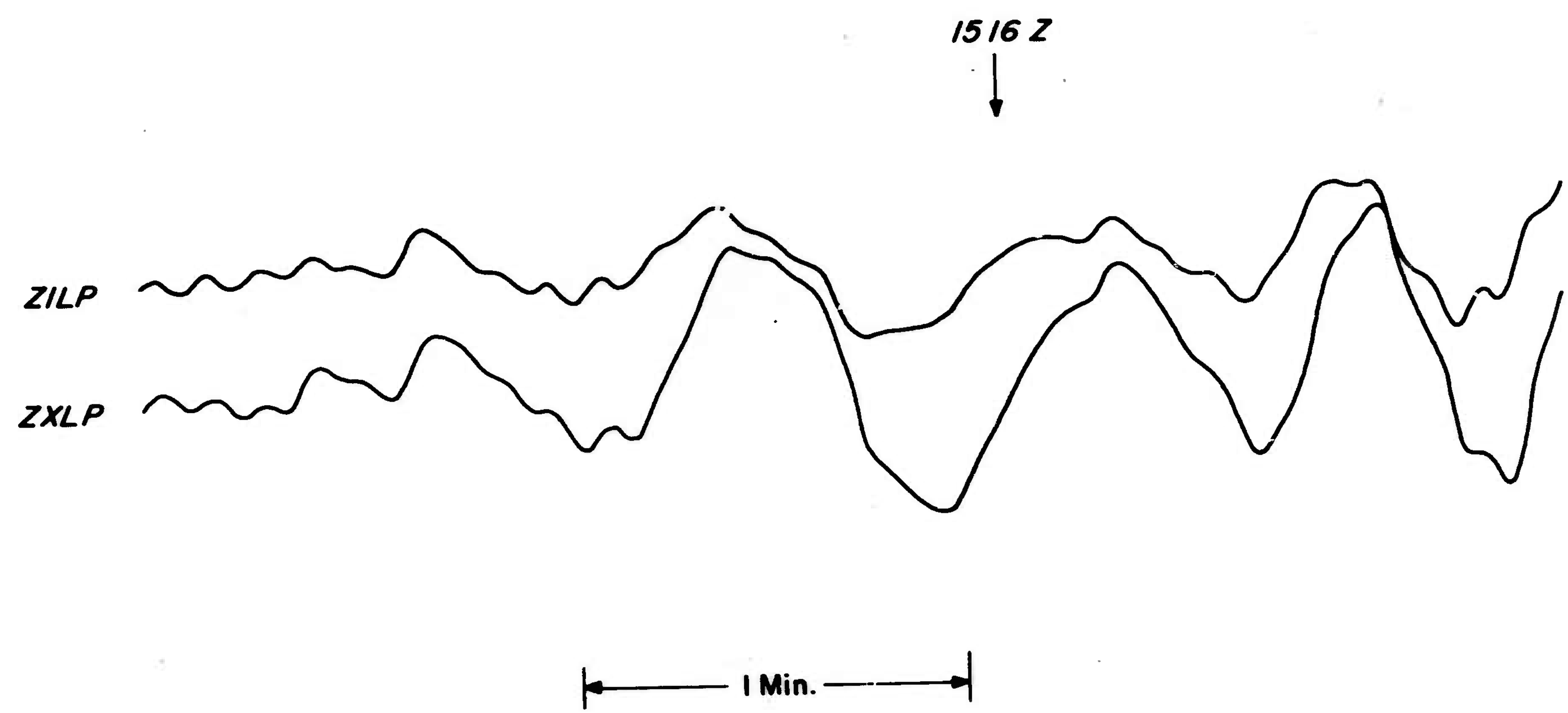


Figure 6. Standard Vela and wide band long period recordings of an event in the south Atlantic Ridge on 18 February 1970 at 14:22:58.2Z.

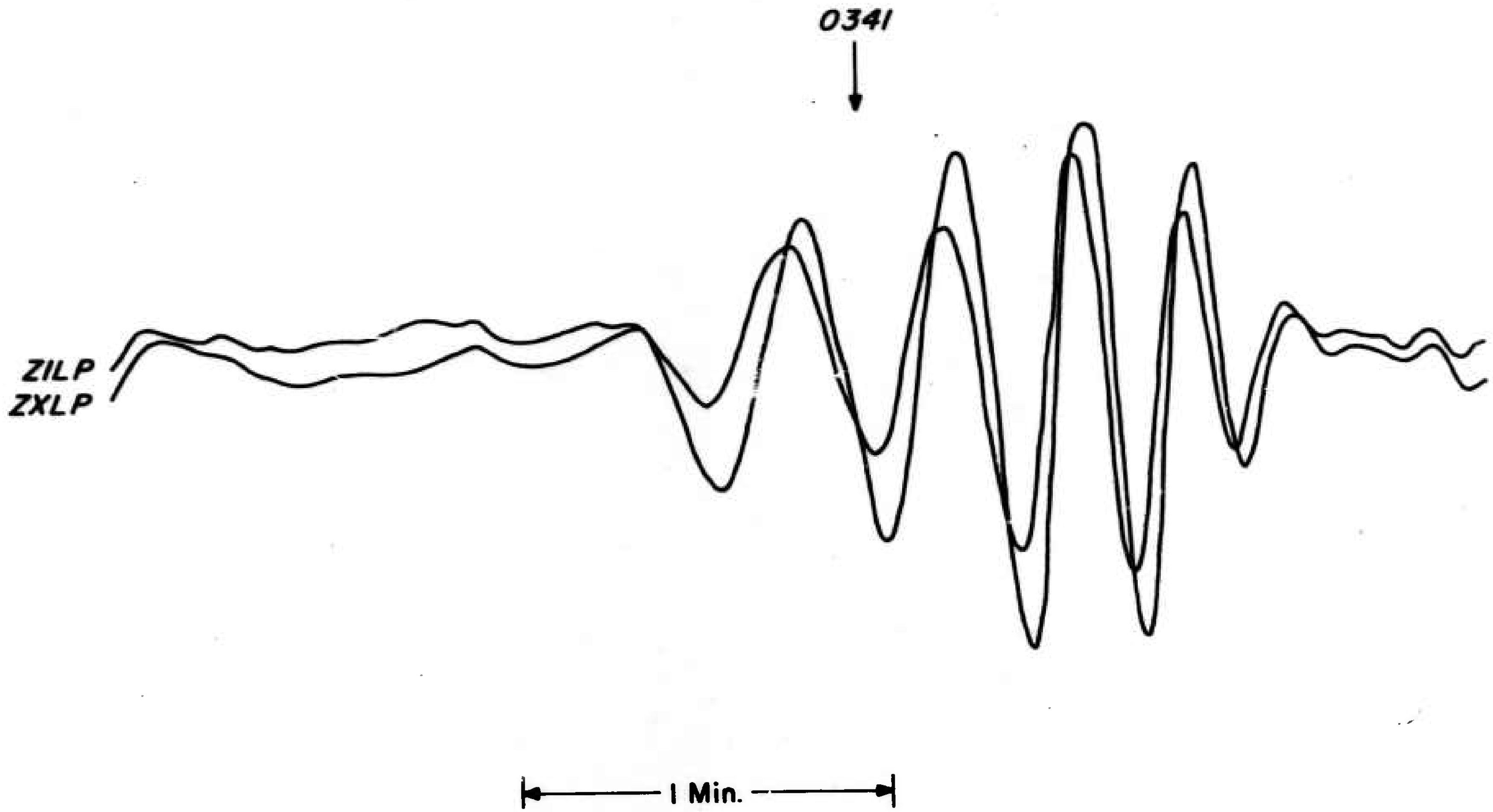


Figure 7. Standard Vela and wide band long period recordings of an event off the coast of Oregon on 22 February 1970 at 03:31:34.5Z.

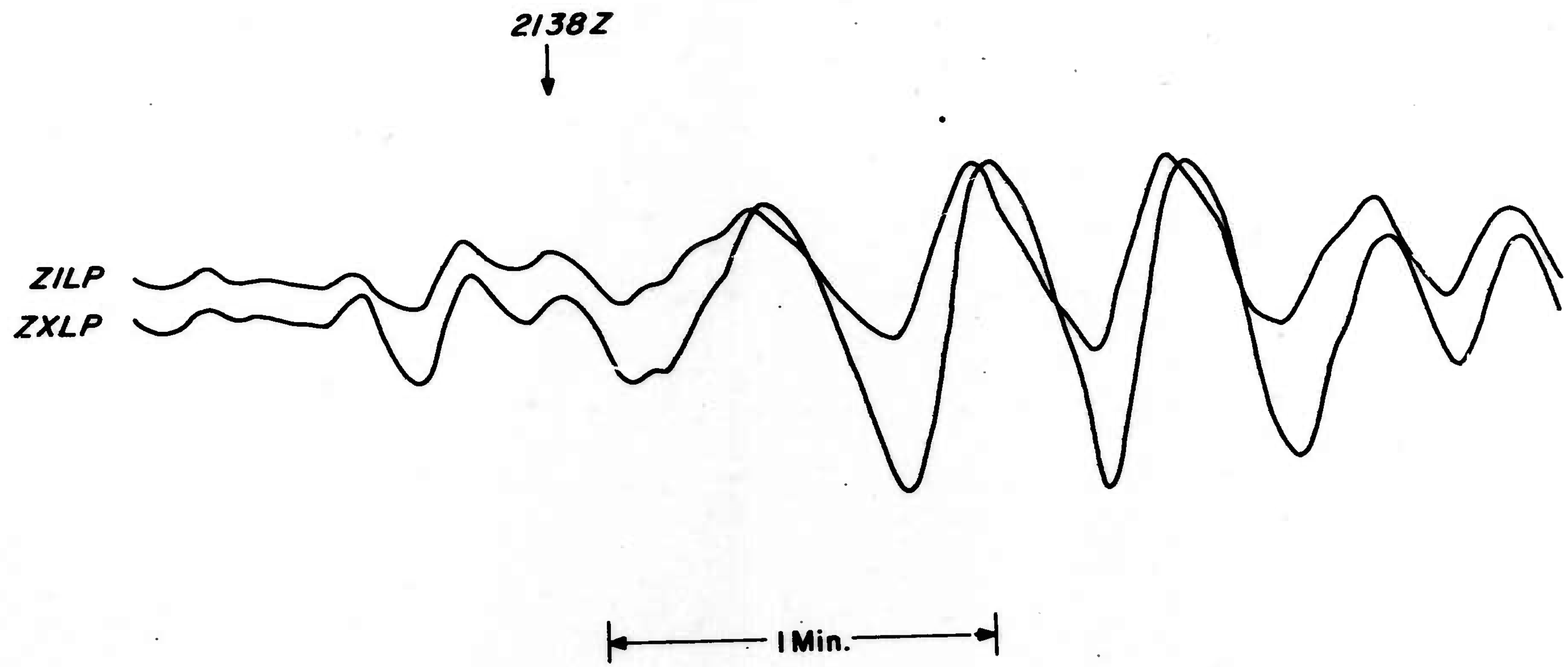


Figure 8. Standard Vela and wide band long period recordings of an event in the Philippine Islands on 23 February 1970 at 20:48:17.8Z.

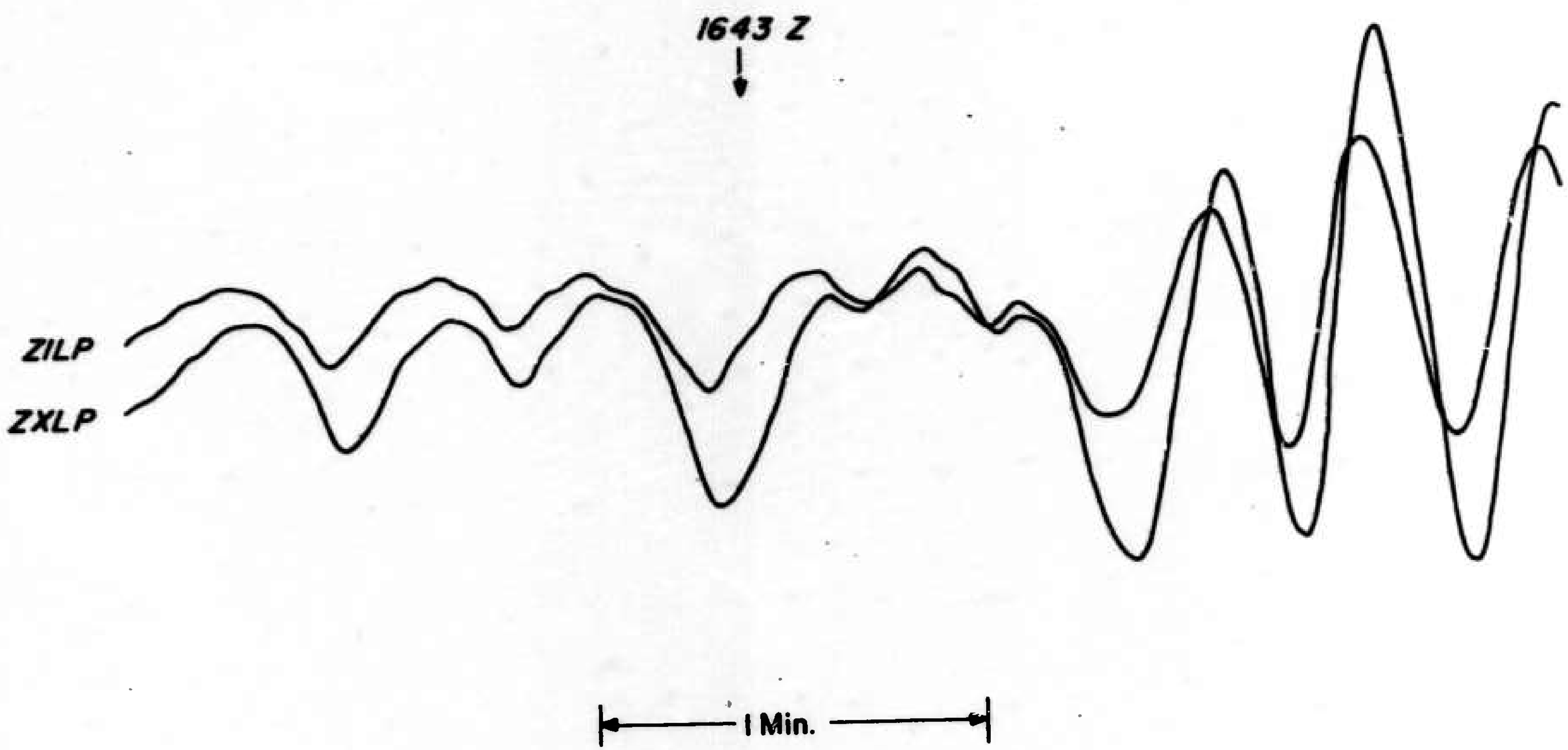


Figure 9. Standard Vela and wide band long period recordings of an event in Mindoro, Philippines on 26 February 1970 at 15:50:11.0Z.

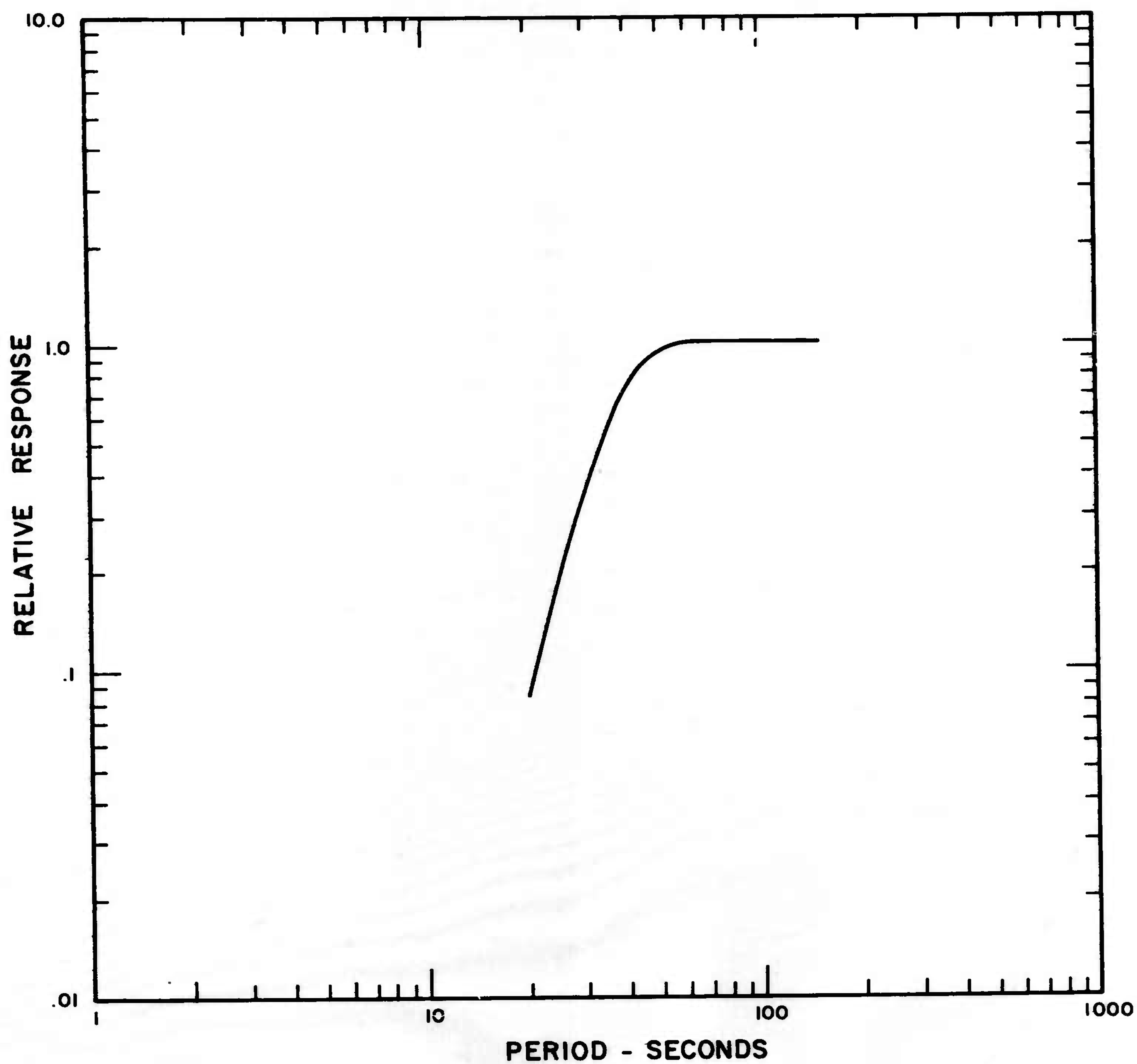


Figure 10. Relative response of the forty second cutoff low pass filter used in the analog processing.

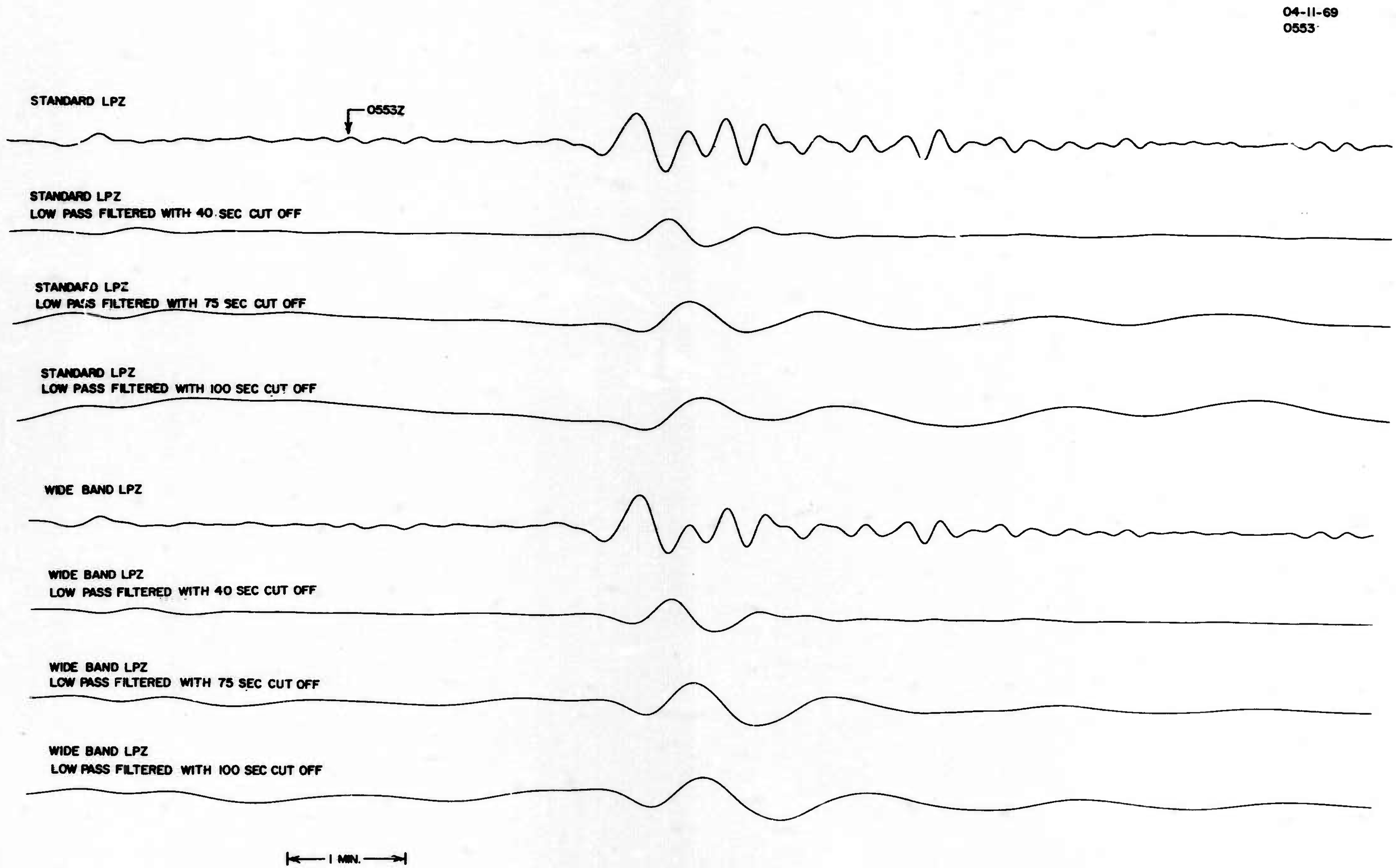


Figure 11. Low pass filtered signals from an event in the central Pacific Ocean 4 November 1969.

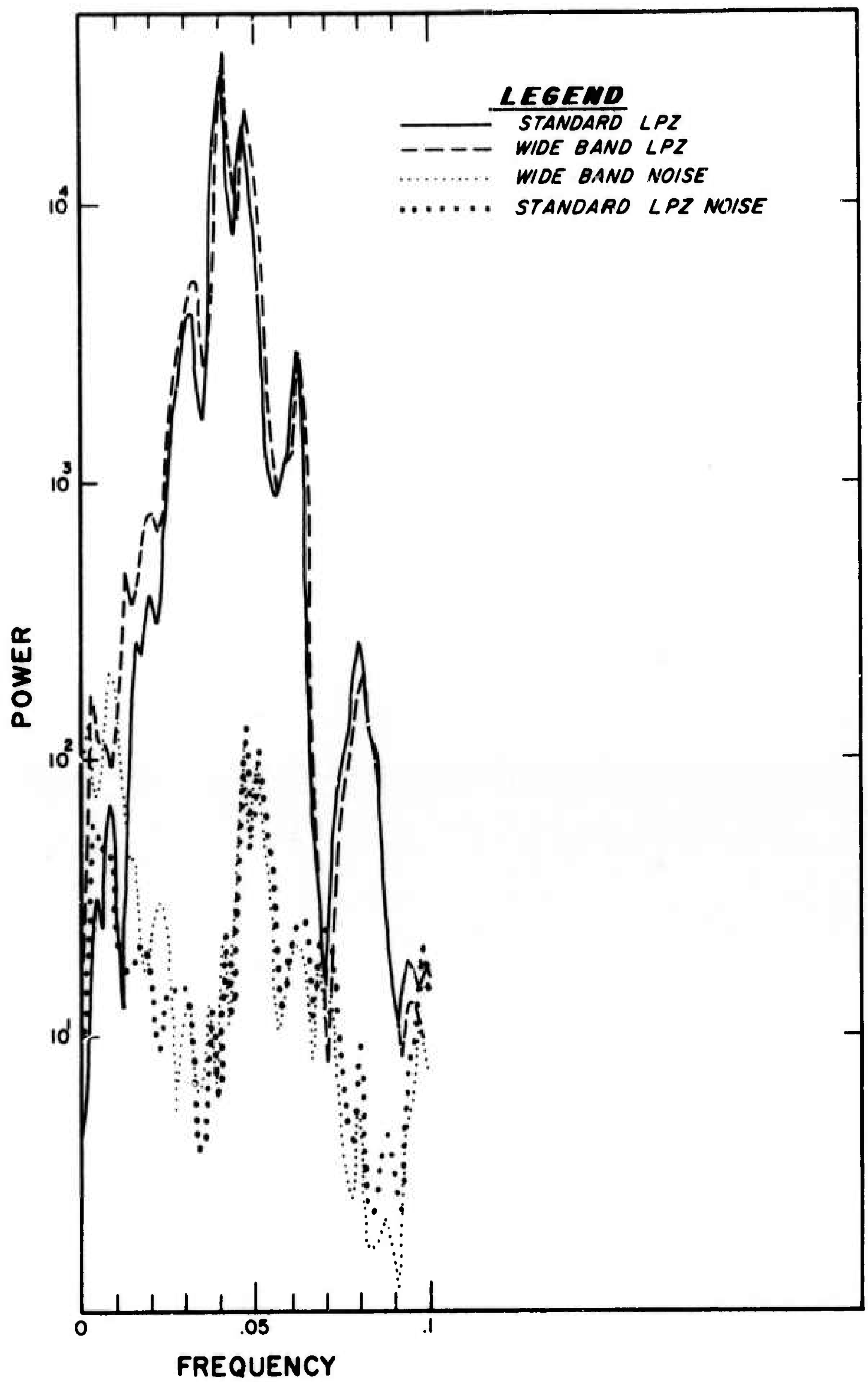


Figure 12. Power spectra of Rayleigh waves from an event in the Philippines on 2 October 1969.

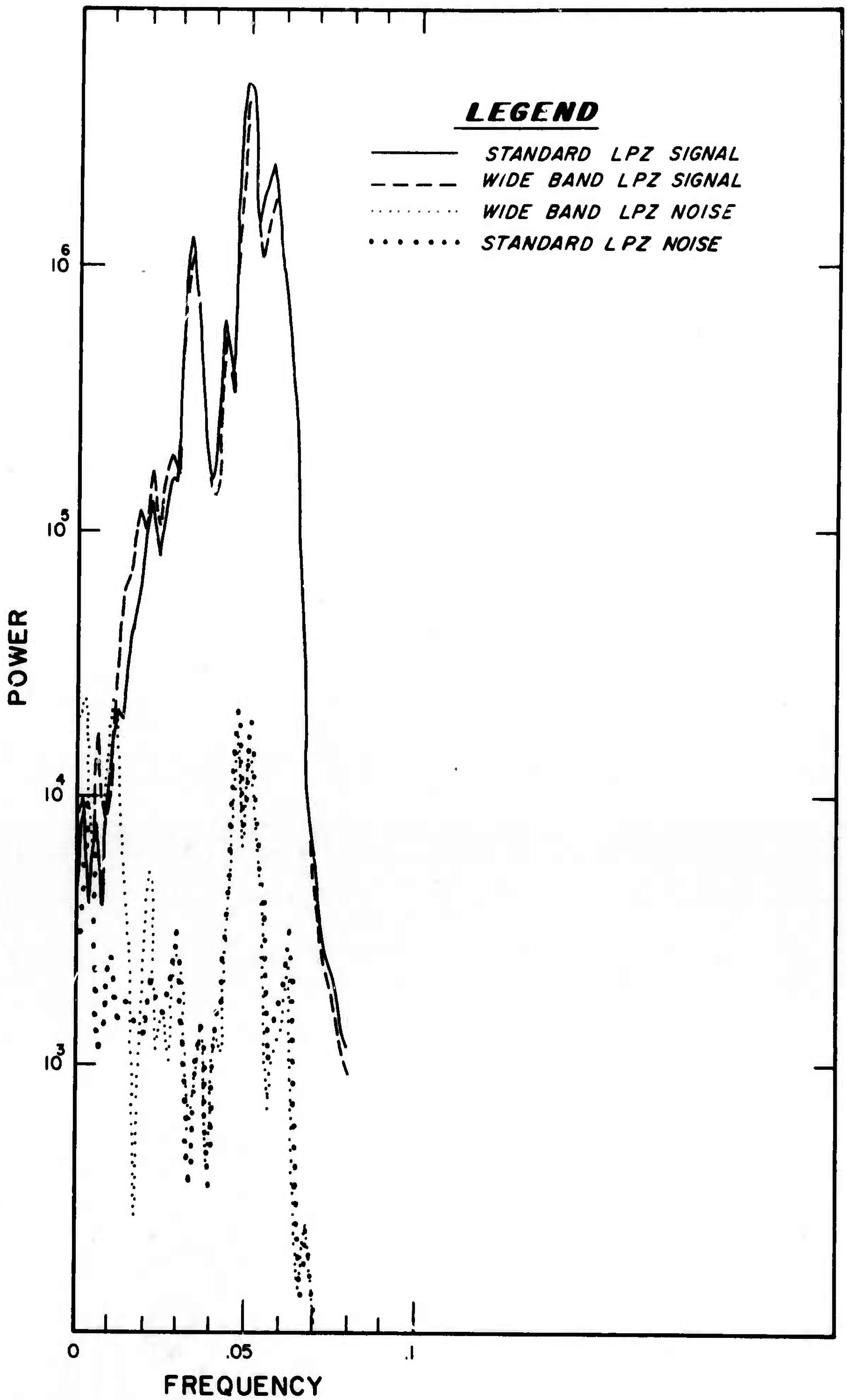


Figure 13. Power spectra of Rayleigh waves from the nuclear explosion MILROW in the Aleutians on 2 October 1969.

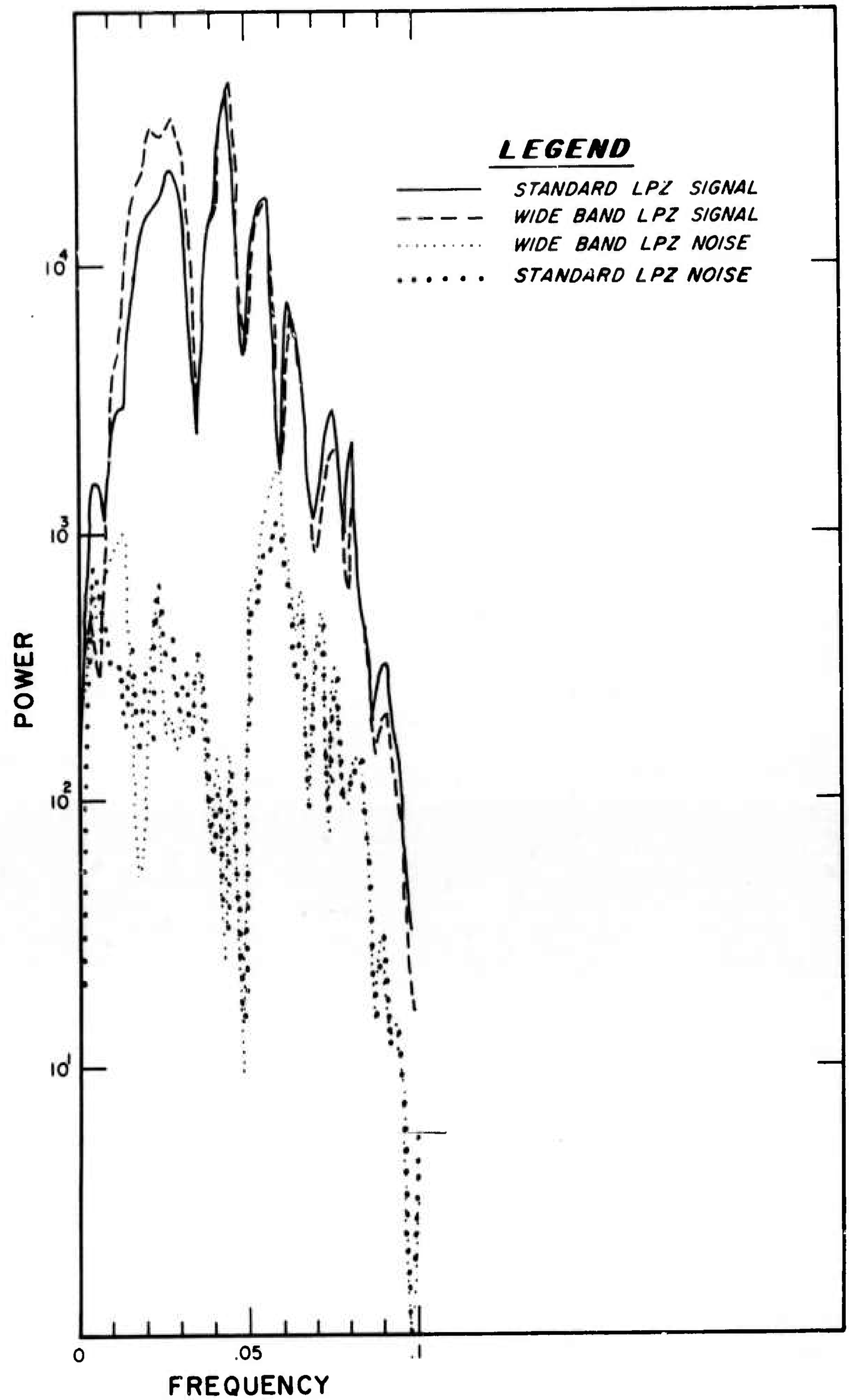


Figure 14. Power spectra of Rayleigh waves from an event in the central Pacific Ocean on 4 November 1969.

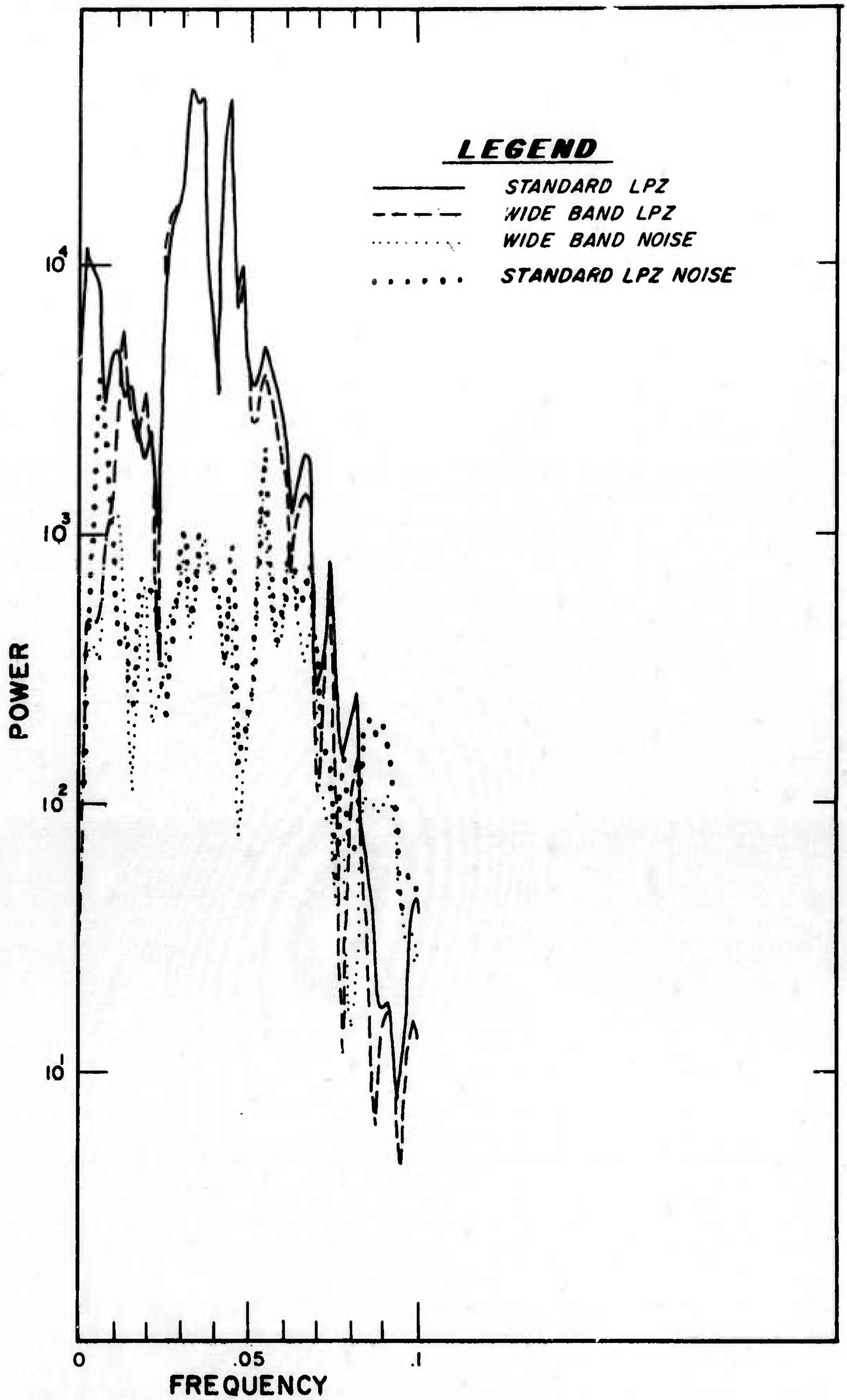


Figure 15. Power spectra of Rayleigh waves from an event near the coast of northern Chile on 15 February 1970.

TABLE I

Source Parameters and Longest Rayleigh Period for Some Events

EVENT NO.	DATE	ORIGIN TIME HR.	ORIGIN TIME MIN.	ORIGIN TIME SEC.	EPICENTER LAT.	EPICENTER LONG.	DEPTH km	MAGNITUDE	GEOGRAPHICAL LOCATION	LONGEST PERIOD OBSERVED STANDARD	LONGEST PERIOD OBSERVED WIDE BAND
1	01 Oct 69	05	05	43.2	11.9S	075.1W	04.0	5.9	Peru	25	32
2	01 Oct 69	09	28	14.0	11.8S	075.0W	03.0	5.8	Peru	33	43
3	07 Oct 69	08	38	34.9	40.4N	125.6W	33.0	4.6	Off Coast of N. Calif.	22	23
4	08 Oct 69	06	32	08.9	12.0N	143.7E	09.0	5.2	S. Marianna Islands	20	20
5	08 Oct 69								UNKNOWN	28	28
6	10 Oct 69	04	06	24.1	13.2N	089.7W	71.0	4.6	Guatemala	35	34
7	11 Oct 69	11	12	34.9	27.0S	176.5W	83.0	4.6	Kermadec Islands	38	37
8	17 Oct 69	22	50	05.7	10.7S	164.7E	63.0	4.8	Santa Cruz Islands	40	38
9	18 Oct 69	08	44	00.0	52.5N	173.5E	24.0	5.6	Near Islands	35	34
10	19 Oct 69	09	05	13.2	51.3N	178.5W	41.0	4.8	Andreanof Islands	33	35
11	20 Oct 69	01	12	23.4	05.6S	153.1E	50.0	4.6	New Britain Reg.	31	33
12	20 Oct 69	11	58	03.0	19.7N	109.4W	33.0	4.7	Revilla Gigedo Island	39	36
13	21 Oct 69	19	52	46.8	12.0N	043.7W	33.0	4.8	N. Atlantic Ridge	45	45
14	22 Oct 69	09	15	48.3	52.6N	158.9E	63.0	4.8	Near E. Coast Kamchatka	37	39
15	22 Oct 69	10	21	52.1	18.1S	071.5W	23.0	5.4	Off Coast of N. Chile	37	35
16	22 Oct 69	12	11	21.3	52.2N	169.4W	33.0	5.1	Fox Islands	35	35
17	23 Oct 69	01	39	22.1	56.1S	027.3W	95.0	5.3	S. Sandwich Is. Reg.	62	62
18	24 Oct 69	20	26	42.5	33.3N	119.1W	02.0	4.9	S. California	30	31
19	25 Oct 69	12	03	47.6	44.1N	147.8E	38.0	5.3	Kurile Islands	35	30
20	25 Oct 69	14	35	08.5	63.3N	145.0W	34.0	4.4	Central Alaska	30	30

TABLE I (Cont'd.)

Source Parameters and Longest Rayleigh Period for Some Events

21	25 Oct 69	17	02	49.7	08.5N	083.0W	37.0	4.1	Panama-Costa Rica	50	52
22	26 Oct 69	02	59	48.5	05.5N	126.6E	80.0	4.8	Philippine Islands	35	40
23	26 Oct 69	03	44	50.4	27.0S	176.5W	30.0	5.3	Kermadec Island Region	37	36
24	26 Oct 69	05	18	52.7	27.1S	176.4W	33.0	5.0	Kermadec Island Region	38	38
25	27 Oct 69	02	55	35.4	45.0N	017.0E	33.0	4.9	Yugoslavia	54	53
26	27 Oct 69	10	59	42.5	36.8N	121.4W	13.0	4.6	Central California	36	35
27	27 Oct 69	13	16	02.3	33.5N	117.8W	06.0	4.5	South California	28	29
28	28 Oct 69	00	22	33.7	34.3N	121.9W	26.0	4.5	Central California	30	27
29	28 Oct 69	11	49	45.7	03.9S	151.6E	19.0	4.9	New Britain Reg.	46	48
30	30 Oct 69	00	47	59.8	22.4N	121.4E	48.0	4.4	Taiwa	35	36
31	30 Oct 69	08	37	38.4	45.5N	027.5W	33.0	4.4	North Atlantic Ridge	62	62
32	30 Oct 69	15	36	19.1	34.2N	120.8W	10.0	4.2	Off Coast of California	18	19
33	30 Oct 69	18	39	23.0	02.[illegible]S	143.5E	33.0	5.2	New Guinea Region	34	36
34	31 Oct 69	08	53	26.3	33.2N	047.9E	51.0	5.0	Western Iran	57	56
35	01 Nov 69								UNKNOWN	28	30
36	01 Nov 69								UNKNOWN	32	32
37	01 Nov 69	09	31	03.5	23.8N	107.1W	33.0	4.1	Gulf of California	36	37
38	03 Nov 69	16	55	19.5	05.8S	154.0E	77.0	5.1	Solomon Islands	31	31
39	04 Nov 69	05	38	03.4	01.9N	100.2W	33.0	4.2	E. Central Pacific Ocean	4[illegible]	42
40	04 Nov 69								UNKNOWN	66	66
41	04 Nov 69	12	05	23.9	51.1N	179.1W	45.0	4.7	Andreanof Islands	27	27
42	05 Nov 69	01	30	03.6	07.9S	156.2E	55.0	5.1	Solomon Islands	39	39
43	06 Nov 69	01	55	43.0	43.6N	147.9E	33.0	4.8	Kurile Islands Region	34	38

TABLE I (Cont'd.)

Source Parameters and Longest Rayleigh Period for Some Events

44	06 Nov 69								UNKNOWN	40	40
45	06 Nov 69	11	33	16.1	05.2N	076.2W	110.0	4.8	Colombia	38	38
46	06 Nov 69	13	01	20.1	15.6N	092.5W	141.0	5.0	Chiapas, Mexico	45	44
47	06 Nov 69	13	13	56.5	15.7N	093.5W	114.0	4.6	Oaxaca, Mexico	53	52
48	06 Nov 69	13	21	21.0	03.9N	032.4W	33.0	5.0	E. Cent. Pacific Ocean	55	54
49	06 Nov 69	14	40	55.5	73.5N	008.0E	33.0	4.7	Greenland Sea	71	66
50	07 Nov 69	12	11	46.5	03.1S	012.0W	33.0	4.9	N. of Ascension Island	38	38
51	07 Nov 69	12	45	35.3	02.9S	012.0W	33.0	5.2	N. of Ascension Island	42	41
52	07 Nov 69	13	04	24.9	02.9S	012.0W	33.0	5.0	N. of Ascension Island	42	42
53	07 Nov 69	16	41	06.7	02.8S	012.1W	33.0	5.3	N. of Ascension Island	42	41
54	08 Nov 69	01	41	41.3	16.2S	167.5E	23.0	5.7	New Hebrides Islands	44	44
55	08 Nov 69	06	31	00.9	03.2N	084.2W	33.0	4.6	Off Coast of Cent. Amer.	48	45
56	08 Nov 69	07	21	29.7	45.5N	150.1E	52.0	5.3	Kurile Islands	41	38
57	08 Nov 69	15	39	13.2	02.8S	011.9W	33.0	4.7	N. of Ascension Islands	27	25
58	08 Nov 69	20	28	23.9	03.0S	012.1W	33.0	5.2	N. of Ascension Islands	43	41
59	09 Nov 69	09	07	50.9	16.3S	167.9E	185.0	5.3	New Hebrides Islands	34	33
60	09 Nov 69								UNKNOWN	85	80
61	09 Nov 69	19	[illegible]	14.8	25.4S	177.2W	190.0	4.5	S. of Fiji Islands	39	39
62	09 Nov 69								UNKNOWN		
63	10 Nov 69	00	30	28.7	15.3S	173.3W	33.0	4.7	Tonga Islands	40	41
64	10 Nov 69	05	36	48.7	02.5S	139.8E	15.0	5.0	W. New Guinea	31	31
65	10 Nov 69	09	19	01.7	16.1S	173.1W	33.0	4.5	Tonga Islands	39	42
66	10 Nov 69	18	15	59.6	77.1N	013.9E	33.0	4.6	Svalbard Region	40	41
67	11 Nov 69	00	30	35.3	33.4N	055.0E	33.0	5.0	Iran	42	43
68	11 Nov 69	02	22	42.9	01.2S	015.9W	33.0	4.8	N. of Ascension Islands	41	42
69	11 Nov 69	06	55	32.6	24.9S	070.6W	39.0	5.1	Off Coast of N. Chile	42	42

TABLE I (Cont'd.)

Source Parameters and Longest Rayleigh Period for Some Events

70	11 Nov 69	15	33	59.2	05.7S	151.4E	73.0	5.3	New Britain Region	36	37
71	11 Nov 69	16	06	03.6	15.5N	119.4E	33.0	4.4	Luzon, Philippine Is.	33	34
72	11 Nov 69	18	01	46.4	62.7W	157.7E	33.0	4.9	Balleny Islands Reg.	45	45
73	12 Nov 69	12	29	42.5	42.4N	144.9E	33.0	5.2	Hokkaido, Japan	40	40
74	12 Nov 69	15	40	15.5	06.0S	148.8E	82.0	5.0	New Britain Region	62	61
75	12 Nov 69	17	11	30.2	16.0S	173.8W	85.0	4.7	Tonga Islands	48	42
76	14 Nov 69	06	52	05.3	04.9N	076.8W	53.0	4.7	W. Coast of Colombia	32	33
77	14 Nov 69	15	37	15.6	14.6S	173.5W	33.0	4.6	Samoa Islands	39	39
78	14 Nov 69	23	56	18.5	07.0N	082.2W	33.0	4.3	Panama	39	36
79	16 Nov 69	05	44	01.6	06.5S	155.0E	63.0	5.0	Solomon Islands	35	37
80	16 Nov 69	16	19	46.5	46.2S	165.7E	33.0	5.2	South Island, New Zealand	37	37
81	17 Nov 69	05	20	50.1	09.9N	125.9E	82.0	5.1	Philippine Islands	42	41
82	18 Nov 69	20	45	41.6	22.3S	175.3W	33.0	4.9	Tonga Islands	41	41
83	22 Nov 69	05	00	39.6	28.2S	177.2W	65.0	5.2	Kermadec Islands	31	30
84	22 Nov 69	19	27	45.9	22.3S	174.9W	33.0	5.3	Tonga Islands	30	31
85	27 Nov 69	00	20	25.5	16.9S	167.9E	41.0	4.8	New Hebrides Islands	29	28
86	27 Nov 69	15	20	04.7	58.0N	163.1E	33.0	4.4	Kamchatka	39	39
87	30 Nov 69								UNKNOWN		

TABLE I (Cont'd.)

Source Parameters and Longest Rayleigh Period for Some Events

88	03 Feb 70	13	34	30.5	17.4S	167.7E	18	4.9	New Hebrides Is.	35	36
89	03 Feb 70	18	55	06.2	17.5S	167.7E	39	5.7	New Hebrides Is.	29	31
90	04 Feb 70	13	07	12.1	43.5N	147.8E	-N-	5.1	Kurile Is.	36	35
91	04 Feb 70	22	45	58.2	22.8S	171.4E	57	5.7	Loyalty Is. Reg.	47	47
92	05 Feb 70	03	40	03.1	24.3N	102.3E	-N-	5.2	Yunnan Prov., China	55	52
93	05 Feb 70	12	46	38.2	47.0N	154.2E	-N-	5.5	Kurile Is.	42	43
94	06 Feb 70	22	10	41.6	23.1N	100.8E	-N-	5.4	Yunnan Prov., China	42	44
95	07 Feb 70	10	01	05.4	47.2N	154.1E	-N-	5.4	Kurile Is.	53	53
96	07 Feb 70	12	07	35.8	47.3N	154.0E	-N-	5.5	Kurile Is.	51	52
97	09 Feb 70	11	26	33.7	16.7N	61.1W	50	5.1	Leeward Is.	50	46
98	10 Feb 70	19	34	05.7	5.9S	130.7E	136	5.7	Banda Sea	44	45
99	10 Feb 70	21	35	56.1	11.2S	166.0E	-N-	4.6	Santa Cruz Is.	38	39
100	11 Feb 70	02	23	48.0	16.2N	96.7W	64	4.8	Oaxaca, Mexico	39	38
101	12 Feb 70	01	27	53.2	3.0S	129.4E	57	5.4	Ceram	43	43
102	14 Feb 70	00	31	59.8	36.9N	121.5W	24		Central California	41	43
103	14 Feb 70	11	17	1..1	9.9S	75.6W	35	5.9	Peru	50	49
104	14 Feb 70	21	03	43.2	19.4N	69.W	117	4.4	Dominican Rep. Reg.	48	47
105	15 Feb 70	03	12	57.7	23.4S	70.2W	56	5.4	Near Coast of N. Chile	32	33
106	15 Feb 70	04	01	34.7	37.4N	141.3E	60	4.8	Near Coast of Honshu	37	37
107	15 Feb 70	12	36	36.7	0.0S	122.9E	154	5.7	Northern Celebes	46	49
108	17 Feb 70	05	46	02.4	9.8N	126.0E	72	5.9	Mindanao, Phil.	40	39
109	17 Feb 70	17	25	01.0	22.2S	170.4E	46	4.9	Loyalty Is. Reg.	34	34

TABLE I (Cont'd.)

Source Parameters and Longest Rayleigh Period for Some Events

110	17 Feb 70	19	14	21.3	22.2S	170.5E	40	5.6	Loyalty Is. Reg.	37	37
111	18 Feb 70	02	07	40.3	50.3N	129.8W	28	4.7	Vancouver Is. Reg.	37	37
112	18 Feb 70	12	56	00.0	52.1N	175.5E	59	5.0	Rat Island	43	43
113	18 Feb 70	14	22	58.2	23.7S	13.4W	N	4.7	S. Atlantic Ridge	52	55
114	19 Feb 70	01	44	18.3	36.2S	53.1E	N	5.4	S. Indian Ocean	58	58
115	21 Feb 70	16	52	00.4	8.6S	124.1E	75	5.3	Timor	65	64
116	22 Feb 70								UNKNOWN	55	54
117	22 Feb 70	03	31	34.5	43.9N	127.9W	N	3.9	Off Coast of Oregon	27	27
118	22 Feb 70	23	41	10.8	71.1N	8.6N	N	5.2	Jan Mayen Is. Reg.	64	64
119	23 Feb 70	11	22	26.2	27.8N	54.5E	20	5.5	Southern Iran	54	54
120	23 Feb 70	19	14	17.4	30.2S	178.5W	N	4.9	Kermadec Is.	41	40
121	23 Feb 70	20	48	17.8	19.2N	121.2E	47	5.2	Philippine Is. Reg.	43	44
122	24 Feb 70	00	36	24.3	22.5S	174.4W	50	5.3	Tonga Is. Reg.	67	67
123	24 Feb 70	15	08	35.5	7.1S	155.6E	42	5.3	Solomon Is.	38	39
124	24 Feb 70	23	18	12.1	34.7S	72.3W	25	5.1	Near Coast of Cen. Chile	45	44
125	25 Feb 70	23	11	01.9	28.8N	43.3W	N	4.7	N. Atlantic Ridge	55	58
126	26 Feb 70	03	03	40.7	13.6S	74.0W	95	5.4	Peru	50	52
127	26 Feb 70	07	35	46.0	13.7S	74.1W	91	5.0	Peru	59	60
128	26 Feb 70	15	50	11.0	13.6N	120.6E	74	5.3	Mindoro, Philippines	61	64
129	03 Mar 70	20	24	02.6	18.3N	100.2W	112	4.1	Guerrero, Mexico	35	38
130	04 Mar 70	01	17	44.5	13.5N	120.4E	61	5.2	Mindoro, Philippines	63	63
131	05 Mar 70	17	01	11.4	18.8S	69.2W	127	5.2	Northern Chile	61	59
132	08 Mar 70	11	51	21.8	1.8N	126.6E	50	5.6	Molucca Passage	39	39
133	10 Mar 70	02	11	07.1	7.8N	126.6E	104	5.0	Mindanao, Philippines	63	60
134	10 Mar 70	08	18	53.8	15.4S	67.2E	N	5.3	Mid-Indian Rise	60	60
135	12 Mar 70	15	40	43.5	4.5S	106.2W	N	4.5	Northern Easter Is. Cordillera	41	41
136	12 Mar 70	18	00	40.6	26.3N	129.5E	40	5.2	Ryukyu Is.	51	49
137	14 Mar 70	01	11	47.0	11.4N	61.5W	70	4.6	Windward Is.	46	49

TABLE I (Cont'd.)

Source Parameters and Longest Rayleigh Period for Some Events

138	14 Mar 70	01	51	44.4	38.6N	44.7E	23	5.3	Turkey-Iran Border Reg.	55	54
139	15 Mar 70	12	39	17.8	29.7S	69.5W	119	6.0	Chile-Argentina Border Reg.	46	47
140	18 Mar 70								UNKNOWN		
141	20 Mar 70	11	07	35.6	5.0N	125.2E	65	5.7	Mindanao, Philippines	34	36
142	21 Mar 70								UNKNOWN		
143	21 Mar 70	10	09	55.4	24.0N	142.7E	N	5.4	Volcano Is. Reg.	37	39
144	23 Mar 70	00	20	54.7	40.1N	140.2E	146	5.7	Honshu, Japan	56	57
145	23 Mar 70	01	52	59.3	21.7N	73.0E	3	5.4	India	72	74
146	23 Mar 70	12	14	53.5	29.8N	129.3E	148	5.8	Ryukyu Is.	66	65
147	24 Mar 70	10	35	22.1	22.0S	126.7E	N	6.2	Western Australia	49	54
148	28 Mar 70	05	16	16.7	35.3S	54.0E	21	5.1	South Indian Ocean	69	68
149	28 Mar 70	07	45	59.9	6.3S	154.6E	64	5.9	Solomon Is.	57	56
150	29 Mar 70								UNKNOWN	59	58

TABLE II

Source Parameters for Events Used in the Analysis of Long Period Energy of Rayleigh Waves

DATE	ORIGIN TIME	EPICENTER		DEPTH	MAGNITUDE	GEOGRAPHICAL LOCATION
		LAT.	LONG.	Km		
02 Oct 69	22:05:40.6	126.8W	9.8N	68	5.3	Mindanao, Philippines
02 Oct 19	22:06:00.0	179.2E	51.4N	1	6.5	Milrow Explosion
04 Nov 69	05:38:03.4	100.2W	1.9N	33	4.2	Central Pacific Ocean
15 Feb 69	03:12:57.7	70.2W	23.4S	56	5.4	Near Coast of N. Chile

TABLE III

Signal to Noise Ratio Determined from Signals Recorded by Wide Band and Standard Long Period Systems

Event	20.0 Sec	25.0 Sec	33.3 Sec	50.0 Sec	60.0Sec	75.0 Sec
Wide Band						
Phillippines	15.1	40.2	17.3	5.8	5.3	2.9
MILROW	17.9	13.4	8.1	5.9	14.1	3.0
Chile	6.7	3.1	5.2	2.5	3.8	4.5
Central Pacific Ocean	5.1	11.5	13.3	14.4	14.9	2.8
Standard						
Phillipines	11.0	47.9	16.2	5.1	3.5	2.7
MILROW	19.4	14.6	3.0	7.6	5.1	3.6
Chile	5.8	2.9	4.5	1.7	2.7	2.7
Central Pacific Ocean	6.2	12.9	8.5	8.0	6.8	4.6
Wide Band/Standard						
Phillipines	1.36	.83	1.06	1.12	1.5	1.08
MILROW	.92	.89	2.7	.78	2.7	.82
Chile	1.15	1.06	1.15	1.48	1.41	1.67
Central Pacific Ocean	.82	.89	1.56	1.80	2.2	.61

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13. ABSTRACT

Analysis of seismic signals recorded on both the standard long period and the wide band long period seismograph systems at TFO revealed that these systems yield equivalent information concerning long period energy in the signals. The Rayleigh wave energy at periods greater than sixty seconds was determined to originate almost entirely from events with epicenters near oceanic trenches or oceanic ridges. ( )

14. KEY WORDS

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