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A STUDY OF TRIGGERED AND UNTRIGGERED EVENTS SPECTRAL DIFFERENCES

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EXTENTED ABSTRACT

Spectra differences between triggered and untriggered events were discovered while earthquake physical modeling. We 've analyzed the spectra of near strong earthquakes with and without foreshocks in Japan Isles region. Accelerograms of normal depth earthquakes with magnitudes of M>6 and epicentral distances from 20 to 350 km were used as original data. Stable valuable differences are discovered between triggered and untriggered events spectra: the former have considerable raising within 12-18 Hz range while the latter smoothly decrease along with the frequency axis. It is likely that such distinctions may be caused by source processes. Possible reasons of the discovered effect are discussed.

Last years the interest in study of induced seismicity, when earthquakes are initiated as the result of oil and gas pumping out, underground mining works, reservoirs filling, nuclear or powerful chemical explosions, increased significantly (Induced sesmicity…, 1987; Nikolaev A.V., Vereschagina G.M., 1985; Adoushkin V.V., 1993). Induced earthquakes problem is of especially significance for industrial regions, where even seismic oscillations of 5-7 magnitude can cause catastrophic consequences including those of ecological nature.

It was determined in laboratory experiments that shock induced elastic oscillations may initiate unstable shifts along rock block contact surfaces, which can serve as earthquakes model (Sobolev G.A., Koltsov A.V., Andreev V.O., 1991). Two main effects were recognizes during these experiments. First, micro-earhquakes initiated in this way arise under lower (up to 30%) mechanical stresses applied to the model, as compared with those necessary for free progress of unstability process. Second, elastic oscillations emitted by micro-earthquakes has much higher frequency band as compared with the natural ones. It was shown in (Sobolev G.A. et al., 1993) that micro-earthquake time delay decreases as initiating shock amplitude increases. Besides, it was found out that acoustic signals appearing while unstable shift preparation process may act as a trigger.

We have some reasons to suppose that earthquake foreshocks may play the same role in the Earth's conditions, and main shocks initiated by them will differ in spectral composition from the earthquakes of the same magnitude without foreshocks. This supposition was under verification in the present work. Accelerograms of the earthquakes in Japan with magnitudes more than 6 and normal source depth, recorded by SMAC type digital stations at epicentral distances up to 65 km were used for analysis. 8 earthquakes with foreshocks and

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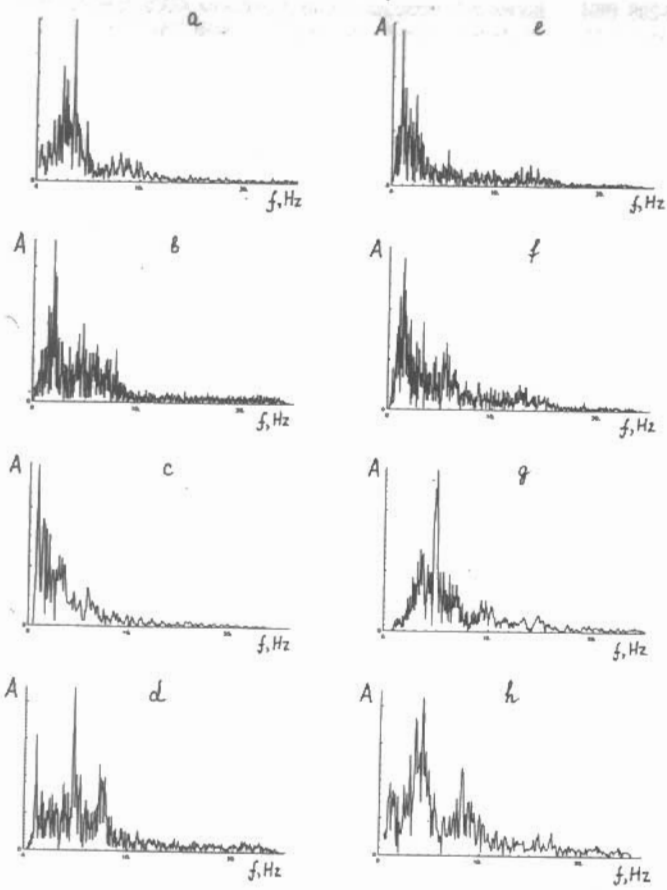

Fig. 1.

Table: Parameters of earthquakes investigated

No	date day,mon,y	time h, m, s	lat N, deg	long E, deg	dept h km	M_b	ep. dist km	stat.
earthquakes without foreshocks								
1	30.04.62	02-26-00	38,730	141,133	35	6,5	64	TH001
2	08.05.63	10-22-00	36,400	141,183	40	6,1	53	KT001
3	16.06.64	04-01-00	38,350	139,183	40	7,5	59	(1)
4	19.04.65	23-42-00	34,883	138,300	40	6,1	21	CB002
5	01.04.68	04-20-00	32,283	132,533	37	7,5	60	KS002
6	01.07.68	10-45-00	35,983	139,433	68	6,1	58	TK056
7	20.01.70	17-33-00	42,383	143,133	25	6,7	46	HK013
8	26.07.70	07-10-00	32,067	132,033	47	6,1	21	KS002
9	04.01.71	21-09-00	34,433	137,167	44	6,1	64	KK026
earthquakes with foreshocks								
1	14.02.56	05-30-00	35,700	139,900	45	6,0	21	TK024
2	05.02.64	11-30-00	36,400	141,067	54	6,0	36	KT001
3	19.11.67	12-07-00	36,433	141,217	48	6,0	50	KT001
4	05.07.68	11-28-00	38,433	142,217	44	6,4	62	TH005
5	21.04.69	07-19-00	32,150	132,117	39	6,5	43	KS002
6	03.03.74	04-05-00	35,567	140,883	49	6,1	39	KT036
7	15.11.74	23-32-00	35,750	141,250	44	6,1	38	KT036
8	20.04.75	17-15-00	33,133	131,333	32	6,4	41	KS014
foreshocks parameters								
1	19.10.55	02-04-23	35,400	140,300	45	5,0	-	-
2	25.01.64	22-48-54	36,650	141,040	53	4,6	-	-
3	10.10.67	06-47-00	36,600	141,120	40	4,9	-	-
4	12.06.68	14-45-01	38,800	142,300	35	4,8	-	-
5	25.03.69	20-24-48	32,100	131,900	43	4,5	-	-
6	22.12.73	23-21-44	35,080	140,760	-	4,3	-	-
7	22.10.74	07-12-31	35,680	140,800	-	4,1	-	-
8	23.01.75	11-58-58	32,980	131,080	-	4,5	-	-

9 earthquakes without foreshocks were analyzed in total. When doing this, earthquakes of less magnitude happened in the source area of main shock (within the first tens of kilometers) with forestall of several months against the following main shock were regarded as foreshocks. Parameters of earthquakes investigated are presented in the table.

SMAC instrument frequency characteristics allow to analyze accelerations spectra within the frequency range of up to 25 Hz. Oscillations spectral composition depends significantly on earthquake magnitude, source depth and epicentral distance. Providing these parameters are close one may compare earthquakes spectra. Power spectra of 8 earthquakes of practically equal magni-tude 6.0-6.1, which sources were located at comparable depths and distances from recording stations, are shown on Fig. 1.

Comparing spectra on Fig. 1a-d (with foreshocks) with Fig. 1e-h (without foreshocks) one can see in the latter local maxima at 12-18 Hz frequencies, which are absent in earthquakes spectra without foreshocks. Moreover, this fact takes place both for recordings of the same station (Fig. 1a and 1g) and for different stations in the whole range of source depths (from 40 to 68 km) and epicentral distances (from 21 to 64 km). One can conclude

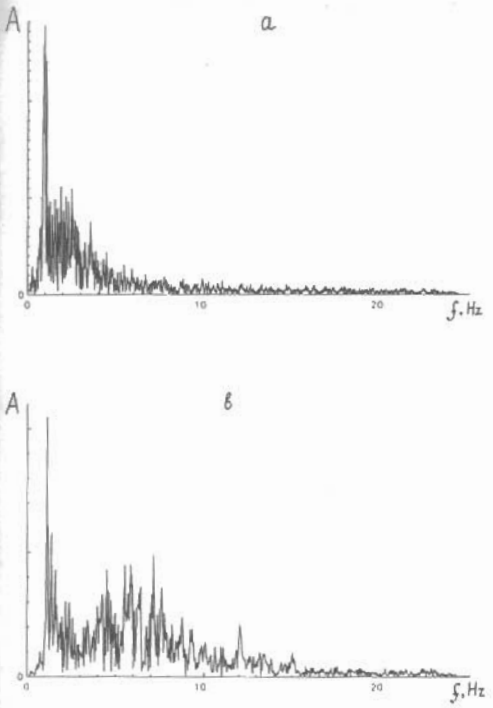

Fig. 2.

that the differences indicated originate from source processes. Similar spectra differences are seen also for higher magnitude earthquakes listed in the table (Fig. 2).

We 've also analyzed normal depth earthquakes records with epicentral distances from 350 to 870 km, which earthquakes had been registered by standard long-period instruments. Record made by the same station were used. Having compared these events spectra one can see at 4-8 Hz frequencies the presence of the effect discovered in near earthquakes spectra, but these differences are' t so clear in comparison with near earthquakes spectra. It's obviously linked both with numerous reflections, absorption, local effects along waves propagation path, attenuating relatively high-frequent source oscillations, and non-optimal frequency characteristics of station instruments with respect to the task of study of spectrum high-frequency part.

After laboratory modeling some suppositions were said out on the following possible triggered impact mechanisms and amplification of high-frequency part of spectra of induced seismic phenomena (Sobolev G.A., Koltsov A.V., Andreev V.O., 1991; Sobolev G.A. et al., 1993). First, an unstable shift of induced earthquake progresses along more rough block contact surface, since irregularities are not smoothed by the creep preceding to usual earthquake. Second, beginning of unstable shift resulting from elastic oscillations action of trigger can be caused by decrease of compressing stresses perpendicular to the contact of by abrupt increase of shift stresses, which leads to quick spread of rupture.

Results of investigation in question show that earthquakes with foreshocks may be considered as initiated ones as well as in case of seismicity induced by artificial factors. Their frequency characteristics depending on source structure differ from characteristics of earthquakes without foreshocks, which must be taken into account in seismic action computations while solving the problem of seismic hazard evaluation and earthquake engineering.

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