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14. *A Short Comment on the 1982 Explosive Eruption of Asama Volcano, Central Honshu, Japan.*

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Abstract

Asama Volcano erupted on April 26, 1982, after a nine-year dormancy. A study is carried out for the three component seismograms of the explosion earthquake associated with the first break which took place at 0225 hours. The seismograms which are corrected for mechanical distortions of recording are available for the spectral analyses by means of Maximum Entropy Method and the results of the analyses are compared with those of the 1973 explosion earthquakes.

As to the spectral analyses on the initial 5-sec part of the 1982 explosion earthquake, it is concluded that a longer period predominates in the U-D and N-S components compared to those of 1973 in spite of its small seismic magnitude. The results may reflect the difference of mechanisms between the 1973 and 1982 explosive eruptions. Taking into account the results of field observations carried out by SHIMOZURU *et al.* or ARAMAKI and HAYAKAWA, no molten magma occurred in the 1982 eruption. As to the spectral structure based on the running power spectra by using Maximum Entropy Method, both the 1973 and 1982 explosion earthquakes roughly have similar spectral structure. This is probably because the spectral structure only reflects the geological structure in the volcanic body.

1. Introduction

Asama Volcano erupted on April 26, 1982, after a quiescence of nine years. The last eruptive activity of the volcano started on February 1 and ended on May 24 in 1973. The activity was outlined by SHIMOZURU *et al.* (1975). A number of volcanic earthquakes associated with the eruptive activity were thoroughly studied (SHIMOZURU *et al.*, 1975; WATANABE, 1976; SHIMOZURU, 1979; IMAI *et al.*, 1979; IMAI, 1980, 1982, 1983a, 1983b).

The present eruptive activity began with the first eruption at 0225 hours and ended with the eruption at 0548 hours on the same day (SHIMOZURU *et al.*, 1982). In this paper, the explosion earthquake associated with the eruption is investigated by means of the Maximum Entropy Method (M.E.M) and the results are compared with those of the 1973 explosion earthquakes.

2. Seismic Data

The seismograms of the explosion earthquake associated with the first eruption examined here were obtained by the three component, medium-period (To=5 sec), displacement-type (Magnification=500) seismographs. The seismographs were installed at NAK which is one of the seismic stations of the Asama Volcano Observatory (A.V.O.). The seismic station is located at approximately 4.2 km east of the summit crater of the volcano (*e. g.* IMAI, 1980, Fig. 1). The seismic data obtained at NAK were recorded on smoked paper drums with a paper speed of 1 mm/sec and their mechanical distortions for the seismic signals due to the finite pen-arm length of the galvanometers were corrected according to IMAI *et al.* (1979).

3. Spectral Analysis

3.1. Predominant Period of Initial 5-sec Part of Explosion Earthquake

Figure 1 shows the waveforms of three component seismograms of the 1982 explosion earthquake whose seismic magnitude was 2.0. Figure 2 also shows those of the 1973 explosion earthquakes which had seismic magnitudes of 2.7 and 2.8 respectively, and were two largest explosive eruptions

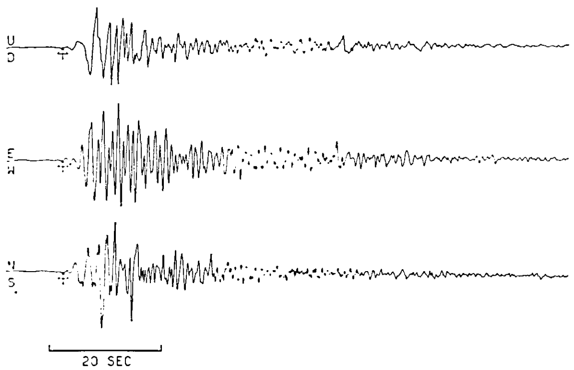

Fig. 1. Three component seismograms of the explosion earthquake associated with the eruption which occurred at Asama Volcano at 0225 hours, on April 26, 1982.

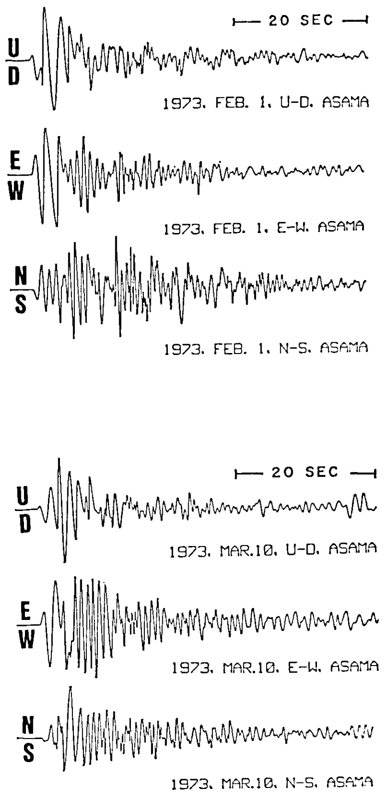

Fig. 2. Two examples of three component seismograms of the explosion earthquakes which occurred during the course of the 1973 eruptive activity of Asama Volcano.

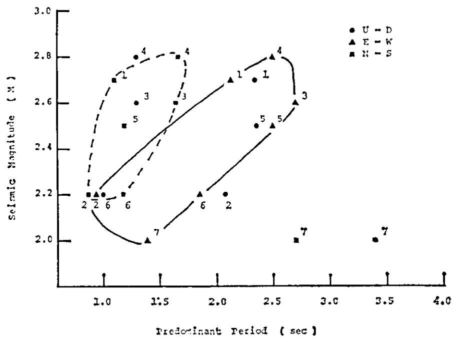

Fig. 3. Predominant periods of the initial 5-sec part of explosion earthquake magnitudes. Numbers, "1" to "6", correspond to the data of the 1973 explosion earthuakes and a number, "7", corresponds to the data of the 1982 one.

during the 1973 eruptive activity. In general, a typical waveform of an explosion earthquake starts with low-frequency (0.5–1.0 Hz) waves with small amplitudes, grows into violent motions with higher-frequency (mostly, more than 1.0 Hz), and gradually becomes weaker. Moreover, no clear S-phases are recognized from the seismograms. The above features are generally different from those of the ordinary tectonic earthquake. According to the visual inspections for original seismograms of the present earthquake, the earthquake seems to have had the above features. A study was carried out for the initial 5-sec part of the 1973 explosion eathquakes whose seismic energy exceeded 10^{15} ergs and the predominant periods of the earthquakes were obtained (IMAI *et al.*, 1979) as listed in Table 1 and shown in Fig 3. Figure 3 shows the relation between the predominant periods and the magnitudes of explosion earthquakes. As to the seismic data shown by the number "1" to "6", an interesting feature can be found in that the predominant period becomes longer with the earthquake magnitude especially in the E-W component (solid line), and a somewhat weaker correlation can be found in the N-S component (broken line). However, the U-D component data show no systematic relationship, though the data have more or less

Table 1. Predominant period of the initial 5-sec part of explosion earthquakes analyzed by M.E.M. (revised from IMAI *et al.*, 1979)

No.	Date		Seismic magnitude	Component of seismograph	Predominant period
	Year	Date			
1.	1973	Feb. 1	2.7	U-D	2.33
				E-W	2.13
				N-S	1.10
2.	1973	Feb. 15	2.2	U-D	2.08
				E-W	0.94
				N-S	0.88
3.	1973	Feb. 20	2.6	U-D	1.25*
				E-W	2.70
				N-S	1.64
4.	1973	Mar. 10	2.8	U-D	1.30
				E-W	2.50
				N-S	1.67
5.	1973	Apr. 18	2.5	U-D	2.38
				E-W	2.50
				N-S	1.19
6.	1973	Apr. 26	2.2	U-D	1.00
				E-W	1.85
				N-S	1.18
7.**	1982	Apr. 26	2.0	U-D	3.39
				E-W	1.39
				N-S	2.70

* additional datum
** data of the present study

a similar tendancy to that found in the E-W component data as mentioned above.

The 1982 data are also listed in Table 1 and are plotted in Fig. 3 as number "7". As to the E-W component, the 1982 data seem to follow the tendancy on the 1973 data. The 1982 data of the U-D and N-S components, however, predominate in much longer periods than in the 1973 data. It is plausible that the above result may be due to the difference between the mechanisms of the 1973 and 1982 explosive eruptions.

The kinds of waves consisting of the initial 5-sec part of explosion earthquakes are considered in the following part. As mentioned previously, the seismic station NAK is located just east of the summit crater of the volcano and the eruptions undoubtedly occurred at the summit crater. Then, the E-W and N-S components represent radial (longitudinal) and transverse components, respectively. Therefore, the above features found in the E-W components may be due to SV-type waves or Rayleigh waves. From the location of the station NAK, on the other hand, the epicentral distance can be taken as 4.2 km, provided that the explosion earthquakes occurred inside a central vent of the volcano. If we assume P- and S-wave velocities to be 2.0 and 1.2 km/sec, respectively, then the Rayleigh wave velocity becomes 1.1 km/sec (EWING *et al.*, 1957, Chap. 2) and the Rayleigh waves will arrive at NAK 1.7 sec later than the onset of P-waves. Thus, it is possible that the initial 5-sec part of an explosion earthquake includes not only P- and S-waves but also Rayleigh waves. Particle orbits would be a powerful method for the determination of the kinds of the seismic waves. However, no useful records for the present study were obtained at the time of the eruptive activity.

3.2. M. E. M. Running Power Spectral Analysis

The variation of power spectral density with time can be easily seen for a running power spectrum. IMAI *et al.* (1979) and IMAI (1980) calculated the running power spectra of the 1973 explosion earthquakes of the present volcano and found conspicuous peaks in the running power spectra at several characteristic frequencies, f_m, obeying an integer-multiple rule based on the fundamental frequency, f_0, as given by

$$f_m = m \cdot f_0 \quad (m: \text{integer}).$$

Figures 4, 5 and 6 shows the running power spectra of three component seismograms of the 1982 explosion earthquake. In the figure, 98×101 squares are used and the squares are dotted, shaded, or black-colored according to the value of the power speciral density which is divided into 10 classes logarithmically in arbitrary unit. The fainter the color, the heigher the spectral peak. It seems that spectral patterns are not very different from those of the 1973 explosion earthquakes presented by IMAI *et al.*, (1979) and IMAI (1980).

The patterns of the running power spectra seem to strongly depend upon the path through which the seismic waves propagate, if the coda waves are considered to be back-scattering waves from numerous inhomogeneities in the volcanic body as pointed out by AKI and CHOUET (1975). From this point of view, the integer-multiple rule found in the running power spectra may appear as long as analyses of M. E. M. running power spectra are carried out for any seismogram of explosion earthquake, which occurs roughly at a similar depth and recorded at the same seismic station.

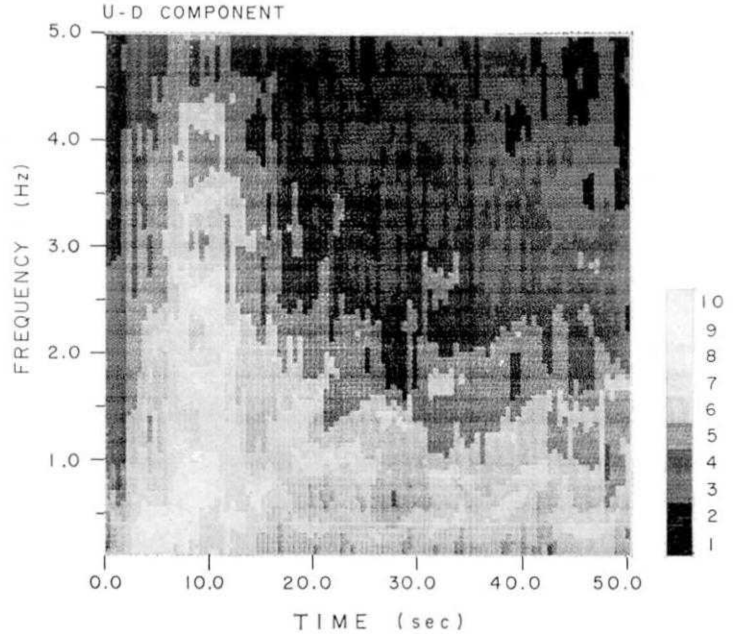

Fig. 4. Running power spectra of the U-D component of the 1982 explosion earthquake seismogram represented by 98×101 squares which are dotted, shaded, or black-colored according to the value of the spectral density divided into 10 classes logarithmically.

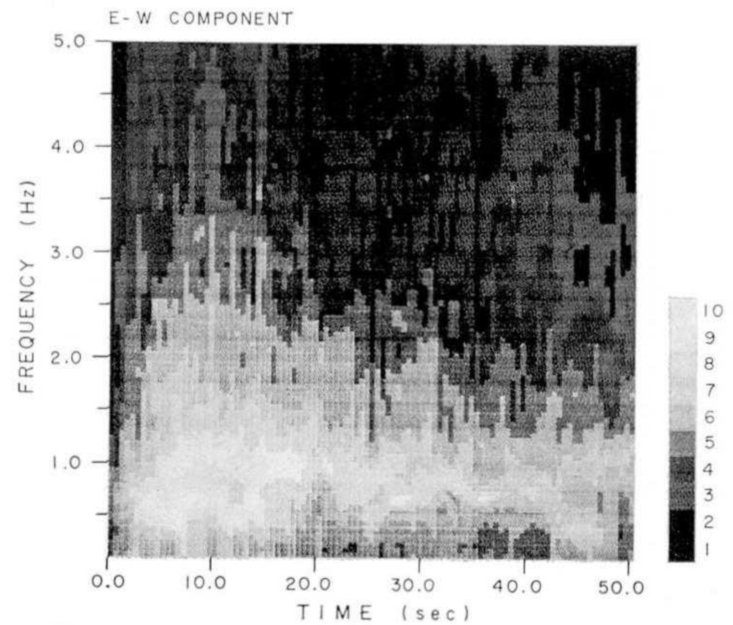

Fig. 5. Running power spectra of the E-W component of the 1982 explosion earthquake seismogram represented by 98×101 squares which are dotted, shaded, or black-colored according to the value of the spectral density divided into 10 classes logarithmically.

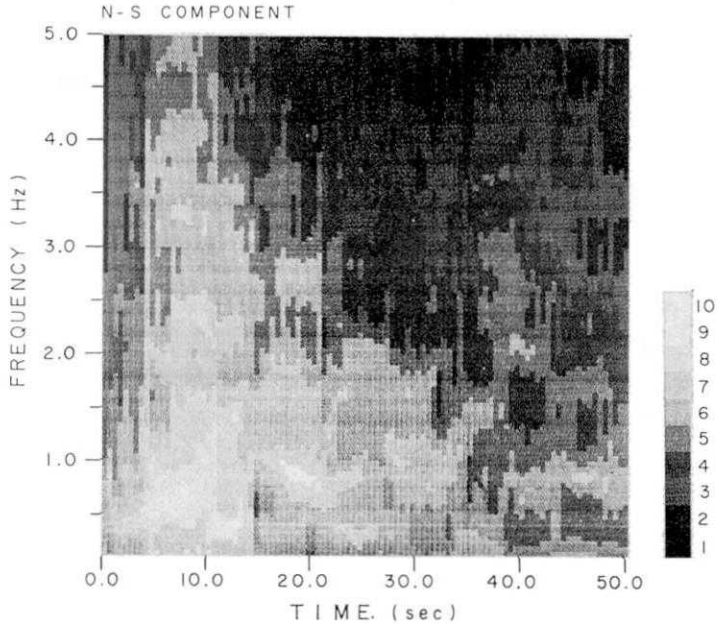

Fig. 6. Running power spectra of the N-S component of the 1982 explosion earthquake seismogram represented by 98×101 squares which are dotted, shaded, or black-colored according to the value of the spectral density divided into 10 classes logarithmically.

4. Discussion

Detail descriptions of the 1982 eruptive activity have been presented by several investigators (*e. g.* SHIMOZURU *et al.*, 1982; ARAMAKI and HAYAKAWA, 1982). In general, it is well known that a swarm of shallow earthquakes, termed B-type, precedes the first eruption of an eruptive activity as occurred at Asama Volcano (*e. g.* MINAKAMI *et al.*, 1959). The 1982 eruptive activity, however, was not preceded by a swarm of shallow earthquakes. The first break, therefore, took place unexpectedly with no precursory phenomena (SHIMOZURU *et al.*, 1982). According to a field survey conducted in the summit area in 1982, no well vesiculated juvenile materials such as pumice or scoria were found (SNIMOZURU *et al.*, 1982), though a large amount of juvenile materials were found in the course of the 1973 eruptive activity. Ash fall deposits ejected from the summit vent during the present activity were studied by ARAMAKI and HAYAKAWA (1982). According to them, a high temperature steam jet deep out of the summit vent may have been responsible for the 1982 explosive eruption, rather than liquid magma.

As to the investigation of the seismic data analyzed in the present study, the predominant period of initial 5-sec part of the 1982 explosion earthquake was much longer than those of the 1973 explosion with similar earthquake magnitudes in the U-D and N-S components. The ratio of the total duration time to the corresponding maximum trace amplitude of the 1982 explosion earthquake was significantly smaller than that of the 1973 explosions of similar magnitudes, which were recorded by the same medium-period three component seismographs installed at the same seismic station NAK (SHIMOZURU *et al.*, 1982).

Judging from the results mentioned so far, it is plausible that no molten magma was directly involved in the 1982 explosive eruption, since no juvenile materials were ejected. A plausible mechanism of the 1982 explosive eruption may be a phreatic or steam explosion, though the idea is not yet determined. Although the cause of the features found from the initial 5-sec part of explosion earthquakes has been attributed to the difference between mechanisms of the 1973 and 1982 explosive eruptions in the present study, the idea is just speculative. However, the results should be worth noting and will be a key in revealing the mechanism of volcanic explosive eruptions. More detailed investigations should be carried out on the mechanism of volcanic eruptions from the wider viewpoints.

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14. 1982年4月26日浅間火山に発生した爆発地震についての簡単な所見

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1973年浅間火山噴火活動に伴う爆発地震の中で地震エネルギーが10^{15}エルグ以上の爆発地震は，その初動部分5秒間の卓越周期が水平動半径方向成分についてその地震マグニチュードと顕著な相関があり，水平動接線方向成分についてもやや相関が認められた一方，上下動成分については顕著な相関は認められなかった．本報文では，1982年4月26日午前2時25分同火山に発生した爆発地震を解析し上述の結果と比較・検討を行なった．

1982年の爆発地震はその地震マグニチュードが小さいにも拘らず，上下動及び水平動接線方向成分に関して1973年の結果と比較すると初動部分に於て著しく長周期成分が卓越していることが判明した．一方，ランニング・スペクトルについて両者を比較するならば，殆ど同様なスペクトル変化のパターンを示しており，両者に何ら相違は認められなかった．以上の事を説明する1つの考えとしては，前述の結果はその発生機巧の違いを反映しており，後述の結果は地震波の伝播する地質学的構造の依存性を示唆しているという考えである．初動部分の卓越周期の研究によれば，1982年の噴火はその発生機巧が1973年の一連の爆発的噴火とは異なり，また野外調査の結果からもマグマの直接的関与が期待できない事を考慮すると，1982年の噴火は水蒸気爆発の類であった可能性がある．さらに詳細な地震学的・岩石学的研究が望まれる．