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Dynamic model of hypocenter vibration and prevision of earthquake
震源振動の動的モデルと地震予知

Toshiaki Kikuchi[1†] and Koichi Mizutani[2] ([1]NDA, [2]Univ. of Tsukuba)
菊池 年晃 [1‡], 水谷孝一 [2] ([1] 防衛大; [2] 筑波大)

1. Introduction

We have examined time-reversal processing in the ocean, and aimed the application of the result to the seismic wave[1)]. Previously, we have examined the hypocenter vibration of the earthquake in Suruga Bay by using the time-reversal processing[2, 3)]. The speed mobile of the hypocenter vibration was clarified from the azimuthal dependence of frequency spectrum of time reversal pulses. In addition, it was confirmed that the amplitude only of the head part of the received signal expanded in the observation station within the narrow range in the moving direction of the sound source. This expansion is caused because pressure is added cumulatively by parametric effects of the hypocenter vibration. As a result, a narrow beam is radiated in the moving direction of the sound source. A dynamic model of a hypocenter vibration has proposed from these results[4)]. This model corresponds to the escalation of the crack caused in an active fault, breaking greatly, and the subsequent process. That is, this model is consistently approved to premonitory symptoms of an earthquake, a main shock, and an aftershock. The effectiveness of this model is verified to four earthquakes that are larger than magnitude 5 that occurred in the vicinity of Mt. Fuji between 2009 and 2012.

2. Dynamic model

Many researches on an active fault and diastrophism are reported. Although the static knowledge is also required, dynamic state observation of an active fault is important for the forecast of a pressing earthquake. Time-reversal processing was executed to the P wave signals received at 44 observation stations that enclosed the hypocenter of the earthquake that had occurred in the central part of Suruga Bay in August, 2009. The pulse formed at the hypocenter position, that is, time reversal pulse (TRP) is obtained. The TRP corresponds to the equivalent sound source that a hypocenter radiates. The TRP obtained from them retained the clear azimuthal dependency unlike an underwater case. To clarify the origin of the azimuthal dependence, frequency spectrum of the

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ads01881@nifty.com

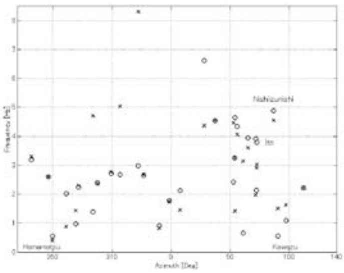

Fig.1 Peak frequency of time reversal pulse to azimuth.
o: EW velocity, x: SN velocity

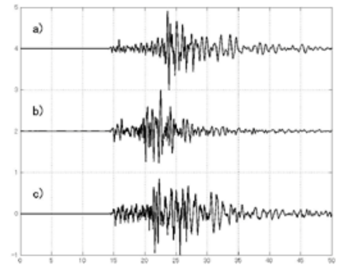

Fig.2 Signal received at parametric spot and near observation station. a): Ito, b):Nishiizunishi, c): Kawazu

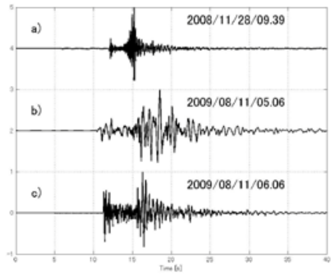

Fig.3 Received signal of precursor, main shock and aftershock at parametric spot.

TRP to the azimuth is obtained. The distribution of the maximum amplitude frequency to azimuth is shown in **Fig.1**. The azimuth sets the north to 0 degrees. The frequency rose greatly and descended after that as the azimuth changed from the west to the east. The rise of the frequency is caused by a fast moving sound source. The received signals at the observation station in the direction in which the sound source moved are shown in **Fig.2**. The expansion of the head part of the received signal only of Nishiizunishi station is seen. The head of the received signals at Ito and Kawazu stations is almost smooth though those stations are near Nishiizunishi station in the position. Nishiizunishi station is the specific observation station to this earthquake. The signals received at a precursor, the main shock and an aftershock at the specific observation station are shown in **Fig.3**. The expansion of such a head occurs when the progression rate of a crack in an active fault becomes near the speed of sound. The pressure that occurs in the crack is added cumulatively with the progress of the crack. That is, it is thought that it causes it by parametric effect. The model shown in **Fig.4** is constructed with these results. The point where the beam of the narrow angle radiated from an active fault reaches the surface of the earth is called a parametric spot. The expanding head observed in the parametric spot is called a parametric head.

3. Model testing

To verify the above-mentioned model, the time-reversal processing is executed to four earthquakes that occurred recently in the vicinity of Mt. Fuji. The TRP and the maximum amplitude frequency of frequency spectrum are obtained. The moving direction of hypocenter vibrations is obtained based on the result. The received signals are examined at the observation stations in the direction, and parametric spots (PS) are obtained. The results are shown in **Table 1**. The parametric spots can be confirmed to all earthquakes. **Figure 5** shows the waveforms of the signals received in each parametric spot. In the parametric spots, Manazuru a), and Komagane c) to earthquakes S3 and S4, a remarkable parametric head are observed. The parametric spot to earthquake S2 is located in the mountainous region and the observation station is a little. However, the waveform received at Nishinohara b) shows the feature. It is clear that the dynamic model of the hypocenter vibration shown in Fig.4 suits all earthquakes that are larger than magnitude 5 that occurred recently.

4. **Premonitory symptoms of earthquake**

The above-mentioned dynamic model is consistently approved for the precursor, the main shock, and the aftershock as shown in Fig.3. Slight earthquakes (magnitude 2 or more) had occurred 17 times in the same source region as it before earthquake S1 (from 2008/1/26 to 2009/8/11). Seven signals to accompany the parametric head in them were observed. These show beginning the movement of a crack in an active fault to a high speed. Therefore, it is thought that it is effective to the prevision of earthquake to observe a slight seismic wave in a specific parametric spot of each active fault, and to examine the change.

5. Summary

The dynamic model of a hypocenter vibration based on time-reversal analysis was

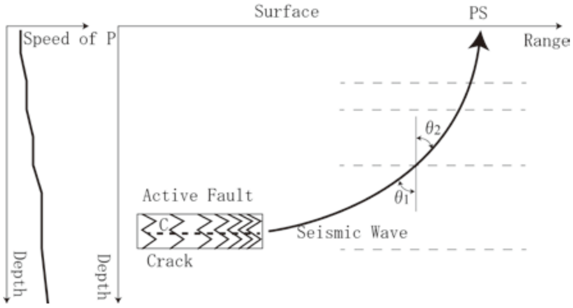

Fig.4 Dynamic model to hypocenter vibration.

Table 1 Specification of earthquakes that occurred near Mt. Fuji.

Earth. Name	Occur. date	Hypo. position	Magni.	P S	Depth km
S1	2009 /8/11	E:138.499 N: 34.789	6.5	Nishiizu-nishi	23.3
S2	2011 /3/15	E:138.714 N: 35.309	6.4	Nishino-hara	14.3
S3	2011 /8/1	E:138.548 N: 34.709	6.2	Manazuru	22.8
S4	2012 /1/28	E:138.977 N: 35.489	5.4	Komagane	18.2

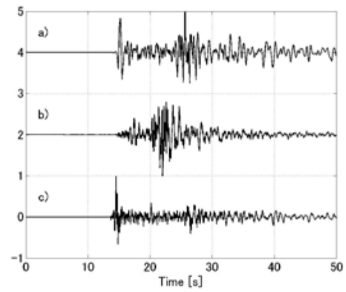

Fig.5 Signal observed at parametric spots.
a):Manazuru, b):Nishinohara, c):Komagane

proposed. The effectiveness was confirmed due to four earthquakes that had occurred recently.

In addition, this model is consistently approved to a precursor, a main shock, and an aftershock. Therefore, the premonitory symptoms of an earthquake can be caught by examining the development of an active fault by observing a slight earthquake of the source region at the parametric spot.

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