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Nonlinearity of hypocenter vibration and prevision of earthquake
震源振動の非線形性と地震予知

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1. Introduction

We have executed time reversal process to seismic waves that occurred in Suruga Bay and analyzed a hypocenter vibration[1,2]. Moreover, we have proposed a dynamic model that pressure added cumulatively by a parametric effect in an active fault, and a narrow beam emitted[3,4]. The model verified about four earthquakes that occurred near Mt. Fuji, and the adaptability shown. In addition, it is shown that the model is effective for prevision of earthquake. The relation between a nonlinear vibration and a radiation pattern of the active fault clarified.

2. Dynamic Model

It is important in the prospect of an earthquake in the near future to know the movement of an active fault. We pay attention to the earthquake that occurred at the center of Suruga Bay in August 2009. Time reversal process added to the P wave signals received at observation stations in 44 places that enclosed the hypocenter, and the pulse formed at the position of the hypocenter, that is, time reversal pulse (TRP) obtained. The TRP corresponds to an equivalent source to which a hypocenter emits. To clarify the origin of this azimuthal dependence, frequency spectrum of TRP to the azimuth obtained. The peak frequency of spectrum to azimuthal angle rises greatly once and descended afeter that. The received seismic wave examined in the observation stations where the peak frequency descended. Only the head of the received signal in Nishiizunishi station in the area expanded. The heads of received signals in Ito and Kawazu near Nishiizunishi are almost smooth. Nishiizunishi is a specific observation station to this earthquake. The head's growing occurs when the progression speed of a crack in an active fault become near the speed of P wave. That is, a parametric effect contributes to the generation mechanism. The dynamic model shown in **Fig.1** derived from these results. The point where the beam of narrow angle emitted from the active fault reaches surface of the earth called a parametric spot. the expanded head observed here called a parametric head.

3. Verification of Dynamic model

The dynamic model verified to four earthquake

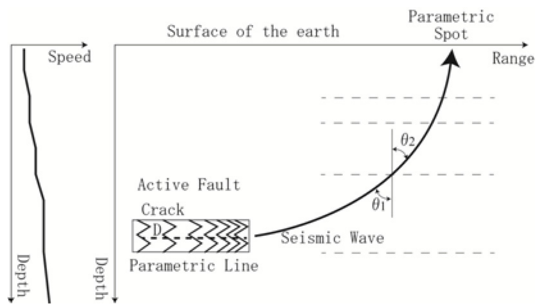

Fig. 1 Dynamic model of hypocenter vibration

that occurred near Mt. Fuji recently. The received seismic waves examined in the observation stations where the peak frequency descended and the parametric spots (PS) obtained. The results are shown in Tabele 1. The parametric spots can confirmed to all earthquakes. However, the observation of the earthquake S1 and S3 is limited because there is no observation station on the seaward side. On the other hand, because the earthquake S4 occured in the inland, the omnidirectionl can observed. The parametric spot of this earthquake is Komagane. The azimuth from the hypocenter to Komagane is 288°. Observation stations divide into a southern part and a northern part on the boundary of the line where Komagane connected from the hypocenter. The peak spectrum frequency of TRP to azimuthal is obtained. **Fig.2**a) is the peak spectrum of TRP in the southern side, and **Fig.2b)** is those in the northern side. Azimuthal angles in the northern side converted into azimuthal angle symmetry in the southern side. After both peak frequencies increase with azimuthal, it decreases. Both figures can considered symmetry as phenomenon. Therefore, it is thought that the source moved along the line of azimuthal 288°.

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

Name	Occur. date	Hypo. position	M	P S	Depth km
S1	2009 /8/11	E:138.449 N: 34.789	6.5	Nishiizunishi	23.3
S2	2011 /3/15	E:138.714 N: 35.309	6.4	Nishinohara	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

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The received signal of earthquake S4 examined in a typical observation station, Komagane, Yokosuka, and Odawara. The range and the azimuth from the hypocenter to each observation station are (96.0km, 288°), (72.3km, 115°) and (28.7km, 156°), in order. The received signal in Komagane (PS) is shown in **Fig.3a)**. The parametric head formed obviously. On the other hand, the received signal in Yokosuka about 180° different from it is shown Fig.3b. The parametric head is seen as well as Komagane. However, the parametric head is not seen in Odawara that is nearer the hypocenter than Yokosuka. That is thought that the wave propagated from the hypocenter to the parametric spot is a beam of narrow angle. The dynamic model applied for all earthquakes shown in Table1. and the parametric head of the received signals in the parametric spots were confirmed.

4. Premonitory Phenomenon

The development of an earthquake appears in the parametric spot of a dynamic model. **Fig.4** indicate the small earthquakes occurred in the same region as S1 from 2008/1/26 to 2009/8/11. The axis of abscissas is an occurring day, and the longitudinal axis is a magnitude. The earthquakes with the parametric head are shown in white, the earthquakes without it are shown in black , and vague waveforms are shown in gray. This figure shows the process to which the crack develops in the active fault. Therefore, it is effective to observe the seismic wave of magnitude about two in a peculiar parametric spot to each active fault, and to examine the change as the prevision of earthquake. On the other hand, the mechanism to which pressure is added cumulatively in the active fault is not clarified. Pavlov[5] analyzed the source that moves by the high-speed in a nonlinear medium, and indicated the Cerenkov radiation and the transition radiation. The frquency of the transition radiation changes to azimuth. The character is similar to the radiation by the active fault.

5. Conclusions

The dynamic model to the hypocenter vibration based on a time reversal analysis proposed, and the effectiveness confirmed at four active faults. The analysis of slight earthquakes in the active fault region on the precursor period is effective for prevision of earthquake.

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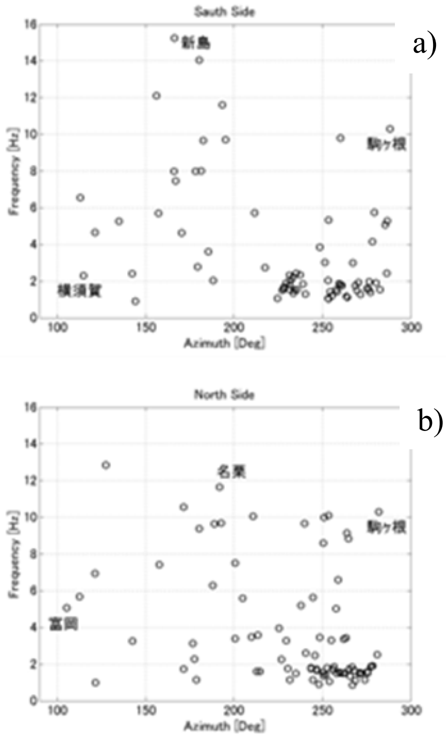

Fig.2 Peak frequency of time reversal pulse to azimuth. a) South side, b) North side

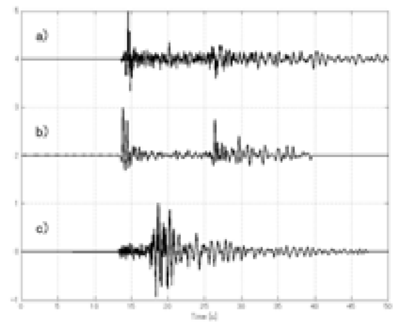

Fig.3 Seismic received pulse
a) Komagane, b) Yokosuka, c) Odawara.

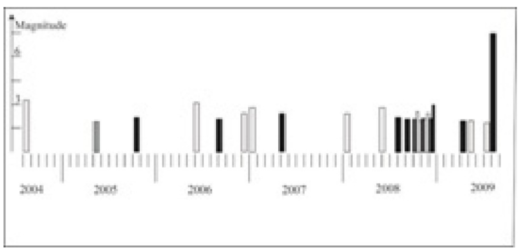

Fig.4 Precursor earthquake and presence of parametric head for S1.

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