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Time reversal pulse of hypocenter and its initial polarity
震源のタイムリバーサルパルスとその初期極性

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

1. Introduction

The vibration of a hypocenter has analyzed based on acoustic knowledge[1-5]. That is, time-reversal process was executed to a seismic wave, and a time reversal pulse (TRP) formed in a hypocenter was obtained. The TRP is equalization to the vibration of a hypocenter, and a dynamic model for vibrations of a hypocenter has obtained from the analytical results of the behavior. In addition, the method of a prevision of earthquake based on this model has advocated. To establish the reliability of these methods, the TRP is evaluated from a seismological knowledge. That is, the structure of a hypocenter is proven as a beachball in seismology. The beachball is substitution of the initial polarity of seismic waves to a ball at the vicinity of a hypocenter. The initial polarity of the TRP is obtained by applying this principle to the TRP, and the results are compared with the beachball. The effectiveness of the time reversal method is shown from those rough coincidences.

2. Vibration of hypocenter

2.1 Beachball

The wave to which the front of a seismic wave is pressurized (push) is emitted in the direction where the crack of a fault compresses a medium. The wave to which the front is decompressed (pull) is emitted in the opposite direction. The initial polarity of the seismic wave received at an observation station is substituted to a ball at vicinity of a hypocenter according to a ray path. The initial polarities substituted from surroundings of the hypocenter form one ball, that is, beachball. The schematic diagram of a beachball is shown in **Fig.1**. The fault structure and the direction of a crack are calculated from the initial polarity distribution on the beachball.

2.2 Time reversal pulse

The time reversal method has many studies in fields such as optics, electromagnetic waves, and acoustic waves. The same wave as a radiation wave is formed at the first radiation point when the wave propagated in a propagating environment is received in a distance, a time reversal processing is given to the received wave, and it emits from the received point in the same propagating environment. The pulse formed at a hypocenter, that is, the TRP

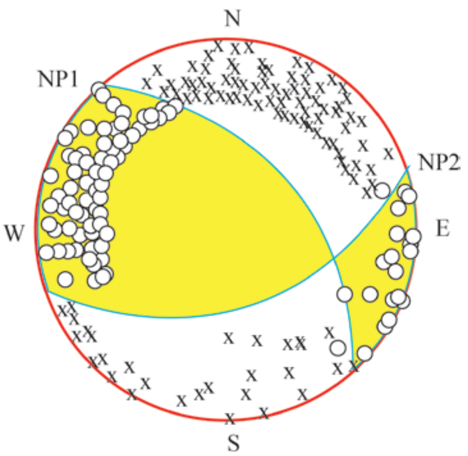

Fig. 1 Schematic diagram of a beachball.
O: Positive initial polarity of seismic wave. (push)
X: Negative initial polarity of seismic wave. (pull)

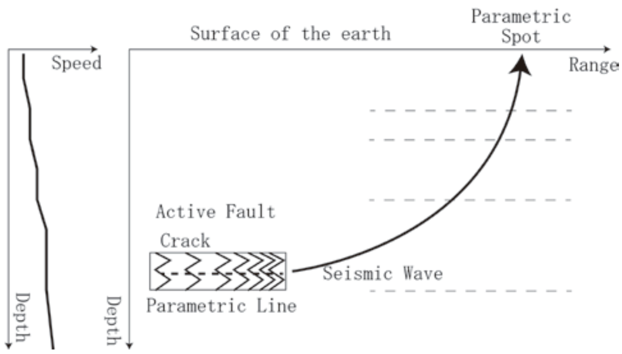

Fig. 2 Schematic diagram of a dynamic model for the vibration of a hypocenter.

is obtained by applying this principle to a seismic wave. The TRP has similar characteristics to the beachball. However, those techniques are greatly different. The TRP is a solution of the inverse problem based on the time reversal method of the wave theory though the beachball is a solution of the inverse problem based on the ray theory. Even as for each technique, the acquisition of the propagation environment is important. Because the coverage is wide, an average sound speed structure is used for the beachball. On the other hand, a more

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ads01881@nifty.com

regional propagating environment is necessary for the TRP. The velocity structure was calculated by using the robustness of the time reversal[7]. The validity of the velocity structure and our simulation was confirmed with the time axis of the pulse formed at a hypocenter position.

3. TRP and dynamic model

The earthquake that had occurred at the central part of Suruga Bay at August, 11, 2009 was examined. Obtained TRPs showed the substantial change to the azimuth of observation stations. The TRP is an equivalent to seismic focus vibration. The variation of TRPs to the azimuth of receiving points is not observed though many experiments concerning the TRP are performed in acoustics. Then, the amplitude maximum frequency is obtained for the frequency spectrum of TRPs to examine the variation to the azimuth of TRPs. This frequency is called a peak frequency (PF). The converging azimuth of radiation waves is obtained from the distribution of the peak frequency to the azimuth[1]. When the seismic wave was observed at the observation station located in the converging azimuth, the wave to which the head expanded was obtained[3]. This expansion is caused because pressure is added cumulatively by the parametric effect in an active fault. This expansion is called a parametric head (PH). The dynamic model of the seismic focus vibration that showed in **Fig. 2** was constructed by analyzing this phenomenon. In addition, the characteristics of the model were examined for four earthquakes that had occurred at the vicinity of Mt. Fuji in recent years[3]. And, it was shown that those all suited the dynamic model. On the other hand, a beachball is used for the vibration analysis of a hypocenter. This is substitution of the initial polarity of seismic waves to a ball at the vicinity of a hypocenter. This technique is applied to the TRP. Because the TRP was wideband signal (1-20Hz), the high-frequency component was removed with low-pass filter (1-2Hz). The initial polarity of the obtained signal was examined. The results are shown in **Fig.3** by open circles (o) (push) and crosses (x) (pull). NP1 and NP2 in Fig.3 show the azimuth from the beachball to this earthquake that the Meteorological Agency published[6]. Most distribution of the o and x coincidences to those of the beachball of the Meteorological Agency. The o of the beachball (push) is distributed between NP1 and NP2. The x (pull) is distributed within this range in Fig.3. That is, the distribution of the o (push) and x (pull) of the TRP reverses with those of the beachball. This phenomenon is a natural result of causing by reversing of TRP time. The longitudinal axis of Fig.3 shows the peak frequency of the TRP. That is, there is a big azimuth in the wave emitted from the hypocenter, and the parametric effect appears remarkably in a specific direction. The parametric spot of this earthquake is Nishiizunishi (◎mark). NP2 is a direction of the crack of the targeted earthquake[6]. The azimuth of Nishiizunishi is 86°41' and its value close to azimuth (71°58') of NP2.

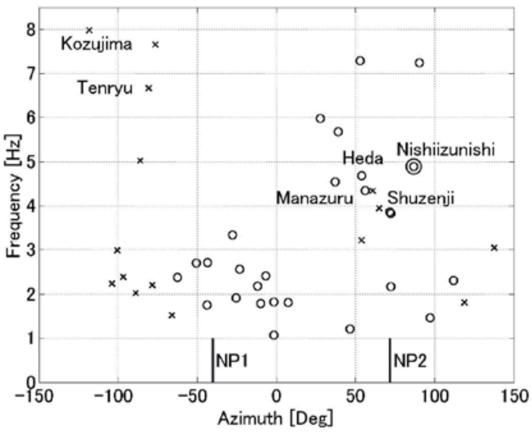

Fig. 3 Polarity and peak frequency of TRPs to azimuth.
o: Plus initial polarity of TRPs.(push)
x: Minus initial polarity of TRPs.(push)
◎: Parametric spot (Nishiizunishi) shown in Fig.1

4. Conclusion

The structure of the vibration of a hypocenter was analyzed by using the techniques of acoustics and seismology, and most result by those techniques coincidences. The beachball is applied to the earthquake that is bigger than M5. The time reversal method can be applied also to a small earthquake of about M2. Therefore, because the progressing process of the crack of an active fault may be observed, it is possible to utilize it for the prevision of earthquake.

Acknowledgement

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