Application of Seismic Interferometry Method to Detect Temporal Changes in the Volcano Structure of Miyakejima

Titi Anggono[1], Takeshi Nishimura[1], Haruo Sato[1],
Hideki Ueda[2], and Motoo Ukawa[2]
([1]Graduate School of Science, Tohoku University, [2]NIED)

Introduction

Seismic velocity is affected by the changes in stress, temperature, fluid contents, etc. In the volcanic area, the eruption is preceded by the increased magma pressure (Patane et al., 2003). Several studies have shown some velocity changes in relation to the volcanic eruption (e.g. Ratdomopurbo and Poupinet, 1995; Nishimura et al., 2005). Those studies were conducted based on the analyses of earthquake multiplets or controlled sources, which need a very long observations or expensive costs. Recent studies based on the seismic interferometry method have been capable of detecting small changes in the velocity structure related with the volcanic eruptions (e. g. Wegler et al., 2006; Brenguier et al., 2008). However, quantitative discussions on the mechanism of velocity changes are few because of insufficient quantitative description of magma activities. Miyakejima Island, which is located about 170 km to the south of Tokyo, Japan, is an active volcano of basaltic magma and experienced an activity in 2000. The activity is well documented and studies based on the geodetic (e.g Fujita et al., 2004; Ueda et al., 2005) , geomagnetic data (Ueda et al., 2006), as well as volcanic gas measurements (Kazahaya et al., 2001) have been conducted. Hence, we analyze the ambient seismic noise recorded at three NIED seismic stations (MKK, MKT, and MKS) in the island in order to study the volcano structure behavior associated with such significant volcanic activities.

Method for Calculating the Cross Correlation Function (CCF)

We apply cross correlation analyses to the continuous records of vertical component of short period seismometers (1 s). The data are sampled at a frequency of 100 Hz with an A/D resolution of 16-bit. We change the data into 1-bit data and calculate the CCF for time window of 60 s for each station pair. We stack the CCFs for each month and bandpass filter the stacked data at frequency band 0.4 – 0.8 Hz and 0.8 – 1.6 Hz.

Characteristics of the CCFs and Temporal Changes in the Structure at Miyakejima

The stacked CCFs, which may represent the Green function between two stations, at station pairs MKK – MKS (the distance is 1.8 km) and MKT – MKS (the distance is 3.9 km) show wave packets with large amplitudes at both sides (positive and negative time delays). The wave packets propagate at group velocities of about 0.7 – 1.0 km/s. The stacked CCFs for MKK – MKT (the distance is 3.1 km) is one sided (negative time delay). Such asymmetric might be due to the inhomogeneous distribution of propagation direction of ambient seismic noise, so we do not use the data for the following analyses. Comparing the CCFs obtained for periods from July 1999 to June 2000 with that of October 2002, we observe travel time difference of the main wave packet. The results show that for station pair MKK – MKS, whose path crosses the northern part of the island, the seismic velocity increased about 1.6 % after the 2000 volcanic activity. For MKT – MKS, whose path closely crosses the newly formed caldera, we estimate the seismic velocity decrease of about 1.5 % (Figure 1). For frequency band 0.8 – 1.6 Hz, we observe similar characteristics. Seismic velocity increase of about 2.4 % is observed at station pair MKK - MKS, seismic velocity decrease of about 0.03 % for station pair MKT – MKS.

Summary

We observed seismic velocity increase and decrease of the shallow volcano structure after the occurrence of the 2000 Miyakejima activity. Such velocity increase and decrease might be caused by the stress increase or decrease in the shallow structure due to volcanic pressure sources, volcanic gas permeation in the volcanic edifice, and other phenomena associated with the activity.

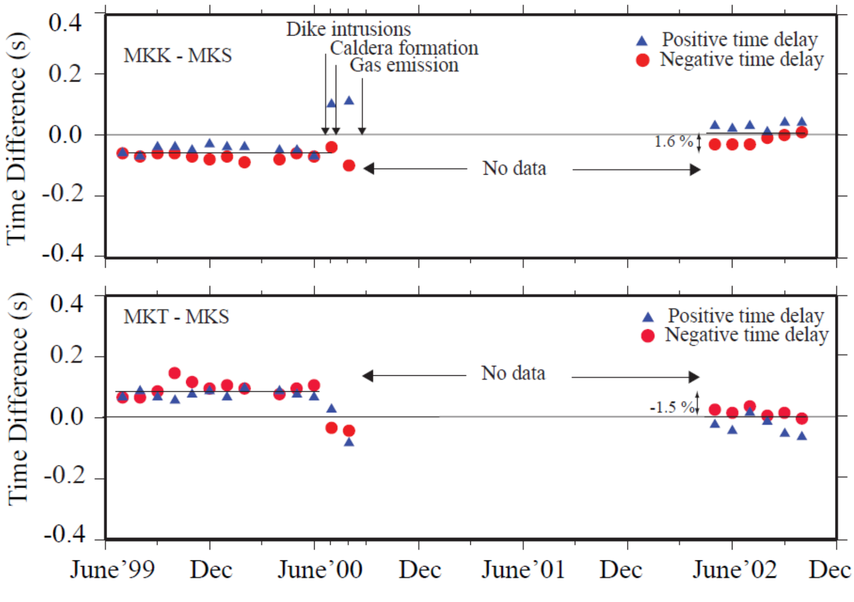

Fig 1. The travel time difference for station pairs MKK – MKS and MKT – MKS for frequency band 0.4 – 0.8 Hz.