Feasibility study for the active monitoring of the temporal change and spatial movement of a magm reservoir beneath a volcano

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1. Introduction

To quantify the temporal and spatial changes of underground geophysical state, we require an integrated mapping and monitoring system (Kasahara et al., in this meeting). A mapping of the crustal structure has been suggested by seismic reflection and refraction experiments by chemical explosive sources, other artificial sources and natural earthquakes. For example, across the central Japan the strong PxP reflection phase from the Philippine Sea plate boundary was identified (e.g., Iidaka et al.2003). The structures beneath volcanoes were also investigated at many sites (e.g., Izu-oshima and Mt. Fuji volcanoes). On the other hand, we have proposed an observation system, ACROSS (Accurately-Controlled Routinely-Operated Signal System), for monitoring under the stable control for a long time period (Kumazawa et al., 2000). The array observation in Tokai area proved to observe the refracted and reflected P and S waves up to 75 km offset distance using two-week long stacking ACROSS data (Kasahara et al., 2004; Tsuruga et al., 2005).

These results encourage us toward the continuous monitoring the magma reservoir and remarkable seismic reflectors in the crust. We here examine the potentiality of the active monitoring of for the magma reservoir and remarkable reflectors beneath a volcano by ACROSS through synthetic seismogram studies of appropriate reservoir models.

2. Simulation on the simple models with a low velocity zone beneath a volcano

At a first step, we discuss the characteristics of wave propagation in the simple structure model including a low-velocity zone (LVZ) as a magma reservoir. We calculate the synthetic seismograms and travel times by FDM method (Larsen, 1992) and by a graph method developed by Kubota et al. (1995), respectively. The model space is 150-km wide and 30-km thick like as an island arc crustal structure. Models have two reservoir types: (A) a sheet-like reservoir with 10-km wide and 0.5-km thick and (B) a lens-like reservoir with 6-km wide and 3-km thick. Each one is located at the depth of 9 km around the center of the space. P-wave velocity, Vp, in LVZ is assumed to be 2 or 3 km/s. Seismic source is located near surface at 10-km offset distance from the center of LVZ and excites a single force in a horizontal plane like a seismic ACROSS source or an explosive pressure.

3. Results

We obtained the preliminary results as follows:

1) In both cases of (A) and (B), remarkable strong S-wave reflections from the upper boundary of LVZ are observed together with relatively weak P-wave reflections and their diffractive waves.

2) Travel times depend on the shape of LVZ

3) Amplitude of the S- and P-wave reflections from LVZ with Vp=2 km/s are relatively larger that with Vp=3 km/s.

4) Larger S-wave reflections from LVZ can be observed at 10-km offset distance from LVZ than those at the farther offset.

5) S-wave reflections from LVZ excited by a horizontal single force have relatively larger amplitude than those excited by an explosion source type.

6) In the model with a LVZ located at 9-km depth, amplitude of a vertical component is larger than the horizontal one.

Thus the travel times and waveforms depend on the shape, properties and location of LVZ and also seismic source types. The remarkably strong S-wave reflections from LVZ particularly recommend us to use S-wave source.

4. Summary

We examined the potentiality of the active monitoring of for the magma reservoir and remarkable reflectors beneath a volcano by ACROSS through synthetic seismogram studies of appropriate reservoir models. The variations of observed amplitude accompanying with the change of geophysical properties and location of LVZ suggest the high potential of continuous and real-time monitoring by the active sources as an ACROSS source and receivers array.