Geothermal structure of the Otake-Hatchobaru area at Kuju Volcano in central Kyushu, Japan, revealed by seismic velocity structure

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1. Introduction

Geothermal activity level of the Otake-Hatchobaru area at northwestern part of Kuju Volcano is high, where geothermal power plants have been operating. Exploiting the power plants, a lot of researchers have carried out geological, geochemical and geophysical investigations. They discussed a geothermal structure at shallower than 1 km below sea level, though didn not do a detail deeper geothermal structure. Then we studied the deep geothermal structure of the Otake-Hatchobaru area based on a seismic velocity structure and seismic activity.

2. Data and analysis

Aso Volcanological Laboratory (AVL) has installed seismic stations in order to observe seismic activity around Aso and Kuju Volcanoes. We used 5,850 earthquakes (43,530 P and 31,408 travel times) during from 1981 to 2002 observed at 47 AVL stations in the central Kyushu. A first model of P wave velocity structure was recalculated with VELEST (Kissling et al., 1994) based on P wave velocity structure of Aso Volcano (Sudo et al., 1985). And a first model for S wave was calculated using Vp/Vs (1.64) by Wadati method from earthquake data. We carried out the tomographic inversion by Zhao et al. (1992). In the tomographic inversion, we had carried out two steps. The first step is to examine in detail the structure of Otake-Hatchobaru area, so the studied volume for this inversion analysis consists of a region around Otake-Hatchobaru area (33.03 degrees - 33.17 degrees N x 131.1 - 131.3 degree E), and we adopted nodes spacing of 0.02 degree in horizontal planes at Z = 1, 3.5, 5, 8, 11 and 20 km depths (Z = 0 km indicates sea level). The second step is to examine the deeper and surrounding structure of the Otake-Hatchobaru area, so the studied volume for this inversion analysis consists of a region around Kuju and Aso Volcanoes (32.7- 33.3 degrees N x 130.75 - 131.45 degrees E), and we adopted two nodes spacing of 0.05 degrees in horizontal planes at Z = 1, 3.5, 5, 8, 11 and 20 km depths.

3. Results

In order to evaluate the influence of the size of grid on the resolution of the velocity inversion, the checkerboard resolution test (CRT) for P- and S-wave was carried out. Good CRT results were obtained around the Otake-Hatchobaru area for depths from 1 km to 3.5 km, and in the eastern region of the area for the layers at 5 and 8 km depths for 0.02 degrees and 0.05 degree node spacing. However, since at 11 km depth, there is no resolution for 0.02 degrees node spacing, we interpreted the velocity structure for shallower part using results of 0.02 degree node spacing and for deeper part using results of 0.05 degree node spacing.

Following the CRT results, we could find some velocity anomaly. For 0.02 degree node spacing, a low Vp and Vs region is located at 1 km depth beneath the Otake-Hatchobaru area. Under the low Vp and Vs region, there are widely a high Vs region at 3.5 km depth and a low Vs region at deeper than 5 km. The low Vs region connects to the Kurokawa geothermal area at southwestern part of the Otake-Hatchobaru area. At east of the low Vs region, a low Vp region linearly distributes from east of the Kurokawa area to the Otake-Hatchobaru area (low Vp line). For 0.05 degrees node spacing, low Vp regions are located beneath Kuju Volcano at 1 and 3.5 km depths. Around the low Vp region beneath Kuju Volcano, a high Vs velocity perturbation is located at 3 km depth. At 5 and 8 km depth, low Vp regions linearly distribute along a volcanic chain from Tsurumi to Aso Volcanoes. We call the linear distribution of low Vp regions as a low Vp line. At west of the low Vp line at 5 km, there is a low Vs region beneath Kuju Volcano. Under these layers, a part of the low Vs region is located at south of Kuju Volcano. There is a low Vp region at the low Vs part (low Vp and Vs region at 11 km depth).

We will present the geothermal structure of the Otake-Hatchobaru area based on these seismic velocity anomalies.