Three-dimensional seismic velocity structure of the upper crust beneath Kirishima Volcanoes derived from local earthquake data

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Sub-Plinian and successive Vulcanian eruptions of Shinmoe-dake, Kirishima Volcanoes, started at January 2011. Before the eruptions, inflation of the volcano edifice had been observed by GPS monitoring network (GEONET of GJI). Combining the data of GEONET and temporal GPS observations, Nakao et al. (2012, submitted) located a pressure source (Mogi model) at 10km depth beneath northwestern part of the volcanoes (5km northwest of the Shinmoe-dake crater) for the period of magma accumulating process before the eruptions. Assuming incidence of plane P waves from regional hypocenters and dividing a target volume into blocks of constant velocity, Yamamoto and Ida (1994) calculated P-wave velocity perturbations on each block. The other previous studies did not map the velocity distributions deeper than about 5km depth by limitations of ray paths. The aims of the present research are to show three dimensional P- and S-wave velocity models below 5km to 15km depth derived from data of local earthquakes and to discuss the obtained seismic velocity structure and relation to the pressure source.

305 earthquakes with 15,221 P phases and 13,649 S phases recorded by 67 seismic stations (Kagoshima Univ., Kyushu Univ., JMA, and NEID in and around southern part of Kyushu) during the period from 2001 to 2012 were selected to perform this analysis. In the 3-D inversion, we applied methods of grid model (Thurber, 1983), ray tracing with Pseudo-bending (Um and Thurber, 1987), Parameter separation (Pavlis and Booker, 1980), and Damped Least Squares (Aki and Lee, 1976). We also referenced results of checkerboard tests and diagonal elements of resolution matrix (DERMs) to delineate velocity models of only areas where the relative reliable velocity distributions seemed to be obtained.

As a result of the 3-D inversions, we obtained reliable P- and S-wave velocities at the depth range of 5-15km beneath the area in and around the volcanoes. Characteristics of the velocity structure at 10km depth are summarized as follows: (1) relative high P-wave velocities (high-Vp, 6.8-7.0km/s) distributed widely beneath the northwest, southwest, and southeast flanks of the volcanoes. The increases of Vp were 10-13 percent, (2) relative low P-wave velocities (low-Vp, 5.3-5.5km/s) areas, 11-15 percent decreases, were delineated beneath the whole areas of the volcano edifices, (3) an obvious low S-wave velocity (low-Vs, 2.7-3.2km/s) area, 10-26 percent decrease, located beneath the northwestern part of the volcanoes. The values of Vp/Vs for the characteristic low P- and S-velocity area were 1.9-2.1 (high-Vp/Vs). The obvious low velocity area contains the pressure source (Nakao et al., 2012, submitted). These features, low-Vp, low-Vs, high-Vp/Vs, and containing the location of the pressure source before the eruptions, suggest that a significant volume of magma accumulation existed at the low velocity area and its environs.