Low-velocity anomaly beneath Kikai-caldera submarine volcano, Japan, revealed by seismic refraction survey

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Kikai Caldera is a submarine caldera volcano located about 50 km south of the Satsuma Peninsula in Kagoshima Prefecture and has repeatedly erupted in large-scale and small-scale eruptions up to the present. Exploration cruises conducted by the Kobe University T/S Fukae Maru suggested the existence of a magma reservoir beneath the present lava dome (Tatsumi et al., 2018). The purpose of this study is to analyze data from a refraction seismic survey conducted in the Kikai caldera, where a magma reservoir is expected to exist, to determine whether a low-velocity anomaly(LVA) exists and, if so, how large it is.

At the end of July 2021, a seismic refraction survey was conducted by the R/V Kaimei of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), and we applied first arrivals tomography (Fujie et al., 2006) to the acquired seismic data. As a result, a 2D P-wave velocity model was estimated just below the survey line, which is approximately 175 km long and crosses the Kikai caldera in the ENE to WSW direction. The obtained model differs in the velocity gradient of the subsurface structure and the depth at which the velocity gradient changes rapidly in four regions (the western part of the survey line, outside the caldera, the western part of the survey line, and inside the caldera), and two features are observed. The first feature is that the velocity gradient increases from the eastern to the western part of the survey line when the velocity structure in the caldera interior is neglected. The second feature is the presence of LVA inside the caldera (about 2-12 km depth) which is as wide as or wider than the caldera itself. Among these features, the velocity model of the ECr11 survey line (Nishizawa et al., 2019), which intersects the survey line, shows a structure indicating the first feature. On the other hand, we do not find any structures showing the second feature, suggesting that the LVA inside the caldera originates from the presence of the Kikai caldera. The size of the imaged LVA was about 25 km horizontally ×10 km vertically, and the maximum velocity reduction was 1.2 km/s (20%). These values were found to be meaningful by the results of a checkerboard resolution test and a Monte Carlo analysis that confirms the dependence of the final model on the initial model. In this study, we considered two possible interpretations of the LVA. The first interpretation is a melted area; the second is a water-filled area of the caldera floor that collapsed during the eruption. However, it is difficult to identify the S-wave velocity values necessary for the second interpretation from this study alone. Therefore, to verify the possibility of the first interpretation, we estimated the temperature anomaly in the LVA based on the assumption that the velocity decrease depends only on the temperature increase. As a result, most of the LVA exceeded the magma temperature of rhyolite (922℃ on average), which is estimated to have existed at depths of 2-4 km below the surface (Hamada et al., 2023). It is unlikely that temperatures exceed magma temperatures, supporting the presence of melts in the LVA. Regions of particularly large temperature anomaly also suggest high melt fraction area. The temperature anomaly is particularly high in the shallow part (about 2-6 km depth) of the LVA, and its horizontal extent is consistent with the width of the lava dome. These results support the possibility that melt could be present in the LVA and indicate that the melt fraction differs between the shallow and deep areas of the LVA, and between the inner and outer areas of the lava dome. In this

presentation, we discuss the difference between shallow and deep areas of LVA by correcting the depth of the source of volcanic earthquakes estimated by a previous study (Seto et al., 2019, JpGU) using the seismic wave velocity structure estimated in this study.

Keywords: Kikai caldera, seismic refraction survey, First arrival traveletime tomography, Low-velocity anomaly

