Hydrophone observations of volcanic activity from the sea area surrounding the Nishinoshima volcano

*Yozo Hamano[1], Hiroko Sugioka[2], Aki Ito[1], Mie Ichihara[3], Masanao Shinohara[3], Kiwamu Nishida[3], Minoru Takeo[3]

1.Department of Deep Earth Structure and Dynamics Research, JAMSTEC, 2.Department of Planetology, Kobe University, 3.Earthquake Research Institute, University of Tokyo

We develop a remote island volcano monitoring system using an autonomous sea-going platform (Sugioka et al. 2016). The system is planned to be capable of observing 1) volcanic eruptions with infrasound signals, 2) deep volcanic activity by seismic signals, 3) eruptive activity by photographs, and 4) ocean waves due to collapse of island slope. During the KR15-03 cruise of R/V KAIREI, we tested the performance of the sensors for these observations. And, five Ocean Bottom Seismometers (OBS) were deployed on the seafloor surrounding the Nishinoshima for more general purpose of monitoring the seismic activity around the volcano. Here, we report the results of the hydrophone observations, which is to be used for observing seismic activity of the volcano.
Hydrophone observation was made at the site 7km east to the Nishinoshima with water depth of 1318 m. The hydrophone was lowered from the ship to the depth of 10m below sea level. During the hydrophone measurements from 2015/2/27 13:20 to 14:40 (JST), videos of the volcano were taken continuously, and both the infrasound recorders on top of the ship and the OBS at the site NI11 14km east to the Nishinoshima were also operating. These simultaneous observations provide a big progress of understanding the role of each observation, and constructing a monitoring system of island volcanoes.
During the observation period, the volcanic activity was very high and eruptions with durations of 20 to 30 seconds occur with the frequency of about 15 events in ten minutes. The sequence of eruptions correlates well with the OBS and infrasound records, suggesting the seismic and infrasound signals are closely related to the eruptive activity at the shallow part of the volcanic body (Ichihara et al., 2016).
On the other hand, the features of hydrophone records are completely different. The most prominent feature of the hydrophone record is the harmonic tremor lasting about 20 minutes, which seem to be generated by deeper activities of the volcano. Underwater sound velocity structure seems responsible for that the wave sources for the OBS and the hydrophone are different. As for the sound velocity structure around the Nishinoshima estimated by the CTD measurement, the sound speed of surface 200 m is almost constant with the speed of 1518m/s. Below this depth, the sound speed drastically decreases to 1480 m/s at 1000m depth, and then slowly increase to 1490 m/s at 2000m depth. This sound speed structure suggests shadow zone at the sea surface depending on the source depth of the sound wave. Assuming that the position of the hydrophone is within the shadow zone, wave source of the explosion earthquakes is estimated to be deeper than 200m, but not much deeper than this depth, whereas the source depth of the harmonic tremor observed by the hydrophone seems to be as deep as 1300m, which is the water depth of the observation site of the hydrophone. It is not clear why the harmonic tremor is not recorded in the OBS. Probably, the T-phase signals are too large due to the low attenuation of the sound wave propagating through the underwater channel. The observation results explained above is extremely important for establishing the observation plan of the remote island volcano monitoring system.

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