Generation and propagation of T-waves associated with underwater volcanic activities

*杉岡 裕子[1]、ロナン ルブラス[2]
*Hiroko Sugioka[1], Ronan Le Bras[2]

1. 神戸大学理学部、2. 包括的核実験禁止条約機関
1. Kobe University, 2. CTBTO

T-waves are defined as seismic recordings of signals traveling an extended path as acoustic waves in the water body of the oceans. This is made possible by the Sound Fixing and Ranging (SOFAR) channel which is a layer of minimum sound velocity acting as a wave guide at average depths of 1000 m. It allows the efficient propagation of extremely small signals over extremely long distances. The existence of the SOFAR channel results from the dependence of the velocity of sound in water on temperature, pressure and salinity. As a result, the detailed structure of the channel varies both geographically and seasonally, but at first order, the SOFAR channel can be regarded as a universal feature of the world oceans. Underwater volcanic activities are thought as one of regular generators of T-waves. The signals may feature a wide variety of characteristics because of the diversity of processes involved during a sequence of the volcanic activities, for example, the opening cracks during the formation of magmatic plumping system, the steady lava flows into the ocean, the oscillation of magma inside the conduit and the supercritical hydrothermal vents.

Since 1999, we have had a lot of long-term seismic array observations on the seafloor at depths of 2500-5000 m using the ocean bottom seismometers (OBSs) with the Guralp CMG broad band sensor, that could record ground motions at period up to 360 s. So far, the continuous data recorded at 100 Hz sampling rate in 1- or 2-year-observation have been obtained at over 200 stations deployed in the Northwestern Pacific, the Philippine Sea, and the French Polynesia region and around the Japanese Island. The T-waves associated with underwater volcanic activities are recorded even on the deep OBSs as a swarm of wave packets absence of P and S waves. Each of the repeated T-waves has duration of 20-30 s with an intermission of also 20-30 s.

Recently, we have had an observation at the vicinity within the range of several kilometers of a current active volcano of the Nishinoshima of the Izu-Bonin-Mariana island volcanic chain. The island erupted above sea level in November 2013. Until November 2015 the island grew up as a result of numerous lava flows. Eruptive activity stopped in November 2015, and no additional activity was observed during 2016. Re-eruption began in April 2017, and continued until the middle of August 2017. Our observations with three or five OBSs have been continuously conducted replacing the locations since March of 2015. The stations located at the depth of 500-2200 m are inside the SOFAR channel because it rises from the 4000-m-seafloor. The records during eruptive periods in 2015 are composed of the hydroacoustic in the water and the seismic surface waves along the mountain slope with dominant frequencies of 10 and 4 Hz, respectively. They correspond exactly to the eruptions in time suggesting that they are generated from oscillations of the shallow conduit just before the eruptions. This is the first detection of the direct waves associated with the eruption in the vicinity and suggests that teleseismic T-waves traveling in the SOFAR channel come from those waves. The International Monitoring System of Comprehensive Nuclear-Test-Treaty has been deployed hydrophone and seismic stations in worldwide since 1996. We use them to detect the teleseismic T-waves from the known underwater volcanic activities associated with the eruptions of the Nishinoshima, which might utilize to understand the propagation of the T-waves.

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