ニューシ゛ーラント゛・ケルマテ゛ィック諸島近海における火山性津波地震による隆起現象

Abrupt Large Uplift Caused by Volcanic Tsunami Earthquakes near the Kermadec Islands, New Zealand

*三反畑 修[1]、綿田 辰吾[1]、佐竹 健治[1]
*Osamu Sandanbata[1], Shingo Watada[1], Kenji Satake[1]

1. 東京大学地震研究所
1. Earthquake Research Institute, the University of Tokyo

Abnormal non-double-couple (NDC) earthquakes are sometimes observed near volcanic or geothermal areas [e.g. Shuler et al., 2013, JGR], some of which generate large tsunamis despite their moderate seismic magnitudes, M5-6. The Torishima earthquakes are ones of the few examples and were attributed to a large crustal uplift associated with some volcanic activity at a submarine caldera edifice on Izu-Bonin Ridge [Fukao et al., 2018, Sci. Adv.; Sandanbata et al., 2018, PAGEOPH]. This type of earthquakes therefore can be regarded as "volcanic tsunami earthquakes."

Another series of volcanic tsunami earthquake were observed near the Curtis and Cheeseman Islands, parts of the Kermadec Islands, north of New Zealand, on 17 Feb 2009 and 8 Dec 2017 (UTC). Tsunamis were recorded at tide gauges and ocean bottom pressure gauges with a maximum amplitude of ~40 cm. The two earthquakes are remarkably similar in seismic magnitudes (M~6.0), focal mechanisms (dominant NDC components), centroid locations (gap of ~10 km) and observed tsunami waves.

In order to investigate their tsunami sources, we numerically solved two-dimensional Boussinesq-like equations with the simulation code, JAGURS [Baba et al., 2015, PAGEOPH]. We first located their source region in the vicinity of the Curtis and Cheeseman Islands, by assuming Gaussian-shaped sea-surface uplifts at 9 locations. We then conducted the tsunami waveform inversion with Green’s functions computed from cosine-tapered uplift distributed around the islands. The estimated tsunami source has a large sea-surface uplift concentrated just over a bathymetric depression that is a characteristic structure of calderas. This suggests a large uplift on seafloor was caused by the earthquakes associated with a volcanic activity of the submarine caldera.

Large uplift events called “resurgence” have been observed at calderas in nature and experiments, which are often attributed to reactivation of ring faults due to overpressure of a magma reservoir [e.g. Acocella et al., 2001, JVGR]. We modeled crustal deformation of a caldera with an interacted system of a ring-fault structure and a shallow sill-like magma reservoir [Liu et al., 2017, AGU Fall Meeting]. Our modeling suggests that the system can cause a large uplift concentrated just over the caldera. The uplift also reproduced tsunami waves similar to the observations, while the gap between seismic and tsunami magnitudes can be explained qualitatively. We therefore suggest that a ring-fault reactivation due to overpressure in a sill-like magma reservoir as a possible mechanism of the earthquakes and their resultant tsunamis.

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