Mechanism of volcanic tsunami earthquake Part I Overview

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1: Tsunami earthquake is a submarine earthquake generating disproportionally large tsunamis relative to its seismic magnitude (Kanamori, PEPI, 1972). Low-angle thrust earthquakes near deep-sea trenches are most typically prone to be tsunami earthquakes. Earthquakes with Mw=5.6-5.7 near Torishima Island, Japan, are tsunami earthquakes in a different category. They repeatedly occur (approximately every 10 years) under a submarine caldera. Seismic and tsunami waves from the most recent event (May 02, 2015) were recorded by the 10 station array of absolute pressure gauges deployed about 100km of the epicenter. Here we present an overview of this observation. The detail of tsunami waveform analysis will be presented by Sandanbata et al. at this session.
2: The instrument has a nominal resolution of 10^(-9) to measure pressure at a water depth of 7000m. The 10 station array is configured to form equilateral triangles with the maximum and minimum lengths of 30 and 10km. The array was installed at bottom depths 1470 - 2240m in May 2014 and recovered in May 2015. This array enabled us to detect a variety of ocean wave phenomena, including semidiurnal internal tide (Fukao et al., JpGU, 2017), ocean infra-gravity waves at periods 50-200s (Tonegawa et al., JGR, 2018) and tsunamis at 100-300s (Sandanbata et al., PAGEOPH, 2018; Fukao et al., Sci. Adv., 2018).
3: The observed tsunami has a dominant period of 200s, for which a roughly one-cycle phase shift occurs across the array, allowing an accurate phase analysis. Measured phase speeds are frequency-dependent in good agreement with the theoretical dispersion curve. If a point source placed within Smith Caldera, the ray tracing calculation can well explain the observed frequency-dependent travel time and incident azimuth to the array. If the source were placed at the caldera rim, the agreement between the observation and calculation becomes worse significantly. The onset of tsunami motion is unambiguously identified as the zero-crossing time prior to the major upswing. Back-projection of this onset using the local long-wave speed map locates its origin at the caldera rim, implying that the uplifted sea surface has its periphery at the caldera rim. The seismologically determined epicenters scatter widely to the east and west of Smith Caldera.
4: We made a tsunami source modeling by solving the Boussinesq equation for a given initial sea surface disturbance. Assuming an axis-symmetric initial disturbance, we made a grid-search for the source radius R and central amplitude A that best explain the observed waveforms. The obtained R is about 4km in good agreement with the Smith caldera size. The obtained A is about 1.5m. The calculated waveforms with these two parameters are remarkably consistent with the observed waveforms. The amplitude of 2cm is in marked contrast to the tide-gauge amplitude of 60cm at a port of Hachijo Island. The simulated tide gauge record again showed a remarkable similarity to the observed record.
5: The reported earthquake mechanisms (JMA, GCMT) are approximately CLVD (Compensated Linear Vector Dipole) with the vertical T-axis with Mw5.7. The expected seafloor uplift from this mechanism is at most 1/20 of the tsunami source height. To explain this large discrepancy, we propose vertical opening of a horizontal tensile fault at a shallowest depth as the plausible mechanism. This mechanism is characterized by (1)poorest far field seismic radiation and efficient tsunami generation, and (2)upward seismic and ocean-acoustic radiations only from the upper side of the fault plane, and (3)Vertical-T CLVD as a moment tensor solution with the assumption of zero isotropic component with a much smaller Mw than expected from the tsunami generation. These characteristics are consistent with those of the 2015

volcanic tsunami earthquake.

Keywords: tsunami earthquake, ocean bottom array observation, pressure gauge