Tsunami generation and propagation caused by Caldera subsidence during 6.5 ka Akahoya Eruption in Kikai Caldera

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The latest caldera-forming eruption in Japan, the Akahoya eruption in 6.5 ka, gave a deadly blow to the prehistoric Kyushu, where a major cultural discontinuity is suggested. We study tsunami generation and propagation caused by the submarine caldera subsidence during the Akahoya eruption from the point of view of numerical and geologic investigations.

Firstly, we assumed some caldera subsidence models concerning notable parameters: the height of pre-eruptive volcano, the subsidence depth, and subsidence duration. The most consistent model inferred from geological data (topography, gravity anomaly, eruptive volume, and eruptive scale) is that a top of a pre-eruptive volcano (15 km*10 km in base and 800 m in height) subsides into 500 m water depth (model 1). Just in case, an 100 m height island subsides into 500 m water depth (model 2), 800 m height subsides into 250 m depth (model 3), and 100 m height subsides into 250 m depth (model 4) are also examined. The durations of caldera subsidence are set to 10-20 s (free fall), 300, 600, 1200..., 1 hour, 6 hours, and 12 hours (uniform velocity) for every model.

Next, we run numerical computations of tsunamis for each collapse model on bathymetry to estimate the tsunami wave heights, waveforms, arrival time, run-up heights, and run-up distance at various locations on the coasts around the Kikai caldera by using the non-linear long wave equations. The bathymetry and geometry data in the computational region is made with a grid of cells 450 m, based upon the bathymetric data of JODC and the altitude data of GSI, taking the sea level in 6.5 ka (10 m higher than at present) into consideration. During the simulation, computed sea levels at 6 min intervals are outputted for entire grid mesh. The following is the results.

For each of the models, the computed tsunami heights near the source are largest for the subsidence duration time 300-1200 s, slightly smaller for the shorter duration, and decrease substantially for the longer durations. There is no significant difference in the shape of the computed waveforms between different duration times for each of the models. Waveforms show a negative first arrival and following positive peaks. In the model 1 (Free fall), a train of waves with elevation of 30 m reached the Yaku Island within 20 minutes, the Satsuma Peninsula within 30 minutes, and the Tanegashima within 40 minutes. In the Osumi Straits and the Tane-Yaku Straits, the water level is 30-40 m. At the south coast of Satsuma Peninsula, the primary wave ran-up 1-2 km on land, and the maximum water surface elevation is more than 30 m. For all of the models with long duration time, the computed tsunami heights are a few meters and cannot run-up all coastal areas.

Computed tsunami run-up heights and distance along the coast, concerning to durations of caldera subsidence, are tried to be compared with the geological studies. Although we surveyed the tsunami deposits on south coast of Satsuma Peninsula and Tanegashima, we cannot discover at present. This fact suggests that large tsunamis have not been generated and run-up because of long subsidence duration, or that even if the tsunami deposits was carried up, return flows have eroded and carried tsunami deposits away. If tsunamis have not run-up, the subsidence durations are estimated at 40 minutes for model 1, 2 and 20 minutes for model 3, 4. Our survey is on going.