The 2018 eddifice collapse event of Anak Krakatau, Indonesia: Telseismic waveform analysis and tsunami simulation

*Shingo Watada[1], Iyan E. Mulia[1], Masumi Yamada[2], Dimas Sianipar[3]

1. Earthquake Research Institute, University of Tokyo, 2. Disaster Prevention Research Institute, Kyoto University, 3. TIGP-ESS Academia Sinica, National Central University, Taiwan

On December 22, 2018 at around 14:30 UT, a tsunami hit the coast of Java and Sumatra islands near the Sunda Strait, Indonesia and claimed more than 400 lives. The Anak Krakatau volcano island in the Sunda Strait erupted coeval with the tsunami and the summit elevation decreased from 300 m before the eruption to 100 m after the eruption, suggesting that the tsunami was generated by the subaerial or submarine edifice collapse of Anak Krakatau. SAR images show that the edifice including the summit collapsed toward southwest and disappeared into the sea. Tide gauge records around the strait suggest that the tsunami was generated at around 13:58. There were no report of a strong seismic event in Indonesia before the tsunami event, although broadband seismic networks in and around Indonesia clearly recorded unusual seismic waves (S-waves and Rayleigh waves) dominated by the long-period (50-100 sec) components. S-waves arrived at the Ryukyu islands at 14:11 and Hokkaido at 14:16. Rayleigh waves arrived at Hokkaido at 14:27. All seismic waveforms indicate occurrence of a long-period seismic event at around 13:56 near Anak Krakatau. Teleseismic body waves hint that the source duration is less than 100 sec (about 1min). Three-component broadband seismic records from four stations near the Sunda Strait can be explained by a near horizontal slightly upward force of $5x10^{11}$ N acting toward northeast for the first 20 sec followed by a near horizontal slightly dipping force of the similar magnitude acting toward southwest for about 50 sec. The force direction and angle is consistent with a collapse model predicted by Giachetti et al. (2012, Geol. Soc. London) in which a resurgent volcano Anak Krakatau collapses into the bottom of submarine Krakatau caldera at 250 m deep along a sliding slope with a dip of 8 deg. The estimated total mass of the edifice collapse is $3x10^{11}$ kg based on the empirical formula between the maximum force and the total mass of landslides (Ekström and Stark 2013, Science). Assuming the soil density 2 g/cm^3 the volume is about 0.15 km^3, roughly consistent with the submarine landslide volume 0.2 km^3 estimated from our numerical tsunami simulation for tide gauge records. Based on the routine seismic monitoring no large earthquake enough to cause tsunami was registered. On the other hand, long-period seismic waves from the seismic event at Anak Krakatau coeval with the tsunamis arrived at Jakarta 40 sec after the event. If long-period seismic events were routinely monitored in Indonesia, we could have detect the edifice collapse of the Anak Krakatau volcano and were aware of the possibility of tsunami generation prior to the arrivals of disastrous tsunamis to the coasts.

Keywords: 2018 tsunami in Sunda Strait, 2018 Anak Krakatau volcano eruption edifice collapse, seismic waves and tsunamis from the edifice collapse, submarine landslide

