

A large slip area of the 1854 Ansei-Tokai earthquake estimated from an observed tsunami waveform at San Francisco

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The great earthquakes have repeatedly occurred at the Nankai Trough subduction zone and caused severe disasters in southwest Japan. Previous studies indicated that the 1944 Tonankai earthquake re-ruptured the large slip area of the 1854 Ansei Tokai earthquake except the plate interface along the Sagami trough (Tokai area). The slip distribution of the 1944 Tonankai earthquake has been studied vigorously using the seismograms of regional strong ground motions and teleseismic waveforms, geodetic data derived from leveling surveys and tide gauge records of tsunami waveforms. However, those instrumental data were not available in 1854. The source process of the 1854 Ansei Tokai earthquake have been only studied from descriptions of earthquake phenomenon in ancient documents such as shaking felt by humans, damage to houses, visual measurements of tsunami inundation or tsunami runup height, and visual measurements of coseismic crustal deformation data. Therefore, the detailed slip distribution of the 1854 Ansei earthquake has not been estimated previously. Then, we have never known that the large slip area of the 1944 Tonankai earthquake is the same as that of the 1854 Ansei earthquake.

Fortunately, a large tsunami generated by the 1854 earthquake propagated through the Pacific Ocean, and was observed at the tide gauge station at San Francisco, USA. In this paper, we determined the source process of the 1854 event using the tsunami waveform data at San Francisco and answer a key question: was a main slip area of the 1854 Ansei Tokai earthquake re-ruptured by the 1944 Tonankai earthquake? If not, what are differences between the large slip area of the 1944 Tonankai earthquake and that of the 1854 Ansei Tokai earthquake?

The tsunami was numerically computed using the linear Boussinesq equations. The grid space was 1.5 minute. First, we fixed the fault model and the slip amount of 4m along the Sagami trough and the deeper part of the plate interface in Nankai trough as same as the previous study (Ishibashi, 1981). Because the previous study determined the fault model using the surveyed coseismic crustal deformation data, the down dip edge of the fault model should be well constrained. Then, the slip amount of the shallower part of the plate interface near the trough was estimated by comparing the observed tsunami waveform with computed one. The results indicate that the slip amount at the plate interface near the trough ranged from 5 to 7m, larger than the slip amount of 4 m at the deeper part of the fault model. The moment magnitude is calculated to be 8.5 assuming a rigidity of 5×10^{10} N/m². The plate interface near the Nankai trough where previous studies estimated the slip amount of 0-1m for the 1944 Tonankai earthquake was greatly ruptured by the 1854 Ansei Tokai earthquake. The result indicated that the plate interface near the trough ruptured by the 1854 Ansei Tokai earthquake was not ruptured by the 1944 Tonankai earthquake. The source process of the 1854 Ansei earthquake is different form that of the 1944 Tonankai earthquake. This indicates that the occurrence of great earthquakes along the Nankai trough is more complicated than that previously expected.

Keywords: the 1854 Ansei-Tokai earthquake, the 1944 Tonankai earthquake, tsunami simulation

