

Similarity and variability of great earthquakes in world's subduction zones

Kenji Satake^{1*}

¹Earthquake Research Institute, University of Tokyo

Because recurrence interval of giant ($M \sim 9$) earthquake is typically several hundred years, data of past earthquakes are limited from a particular subduction zone. However, we can increase our knowledge by studying the subduction zones in the world. For five giant earthquakes with $M=9$ or larger occurred in the world since the 20th century, instrumental data such as seismic waves, tsunamis, or geodetic data were used to estimate the slip distribution and similarities. For older earthquakes, historical documents or paleoseismological data such as coastal movement (subsidence or uplift), tsunami deposit, or turbidite can help to estimate size and recurrence of past earthquakes. They show the variability of past earthquakes: giant ($M \sim 9$) earthquakes occurred in the source regions of recurrent $M \sim 8$ earthquakes, hence it is dangerous to assume characteristic earthquake model (Satake and Atwater, 2007).

For the post 20th century earthquakes, i.e., the 1952 Kamchatka (M_w 9.0), 1960 Chile (M_w 9.5), 1964 Alaska (M_w 9.2), 2004 Sumatra-Andaman (M_w 9.1) and 2011 Tohoku (M_w 9.0) earthquakes, the slip distributions have been estimated from inversion of tsunami and geodetic data. The results show that the largest slip is twice to four times larger than the average slip, and the asperity (defined as the area with more than 1.5 times the average slip) consists 16-32 % of the total fault area. The scaling relations among seismic moment, fault area, asperity area, average slip obtained for $M \sim 8$ earthquakes can be applied for the $M \sim 9$ earthquakes (Murotani et al., 2013).

Paleoseismological studies around the Pacific ocean have revealed the recurrence interval of giant earthquakes. In southern Chile where the 1960 earthquake occurred, historical records indicated that the recurrence interval was ~ 100 years, but recent studies of tsunami deposit (Cisternas et al., 2005) show that the penultimate event occurred in 1575 and the recurrence interval is ~ 300 years. In north America, along the Cascadia subduction zone, no great earthquakes have been recorded in historical records. Numerous paleoseismological studies on coastal subsidence, tsunami deposit or offshore turbidite have shown that more than 40 great earthquakes occurred in the Holocene, but the number of giant earthquakes ($M \sim 9$) is about a half, or the average recurrence interval is ~ 500 years (Goldfinger et al., 2012). Along the Kuril trench, the great earthquakes that left tsunami deposits occurred with ~ 500 year interval, and the most recent one occurred in the 17th century (Nanayama et al., 2003). Tsunami deposit studies in Sendai plain showed that the recurrence interval of giant earthquake similar to the 869 Jogan and 2011 Tohoku earthquakes is 500 to 800 years (Sawai et al., 2012). Similar paleoseismological studies have been made in countries around the Indian Ocean such as Thailand, Indonesia, or India, and they show that tsunamis similar to the 2004 Indian Ocean tsunami occurred several hundred ago. The tsunami deposits in Thailand show that the average recurrence interval is ~ 500 years (Prendergast et al., 2012.)

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