

The 2004 Sumatra earthquake and tsunami in Indian Ocean: seismological questions and future research

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The December 26, 2004, Sumatra earthquake (Mw 9.0) generated tsunamis that propagated across the Indian Ocean and caused the worst tsunami disaster: the casualties over 200,000 mostly in Indonesia, Sri Lanka, India and Thailand.

The earthquake was the largest in the world in the last 40 years. The aftershock zone extended from west of Sumatra through Nicobar Islands all the way to Andaman Islands; the total length is over 1,000 km. Preliminary analyses of seismic body waves (websites of Yagi, Yamanaka, Ji, and Ruff) indicate that the source duration was at least 200 sec (time window usable for P wave analysis) and the fault extended ~400 km from the epicenter. It is thus very important to estimate the fault length from longer period surface waves or free oscillation data. If the fault was extended to Nicobar or Andaman Islands, coseismic changes (e.g., uplift) must have occurred and recorded as shoreline changes. Field investigation on these islands would help to accurately estimate the fault length hence the earthquake size. Such gigantic earthquakes in the Pacific (e.g., the 1960 Chilean or 1964 Alaskan earthquakes) produced decade-long, meter-size postseismic deformation have produced decade-long postseismic movements that can be detected by GPS observations. The tsunami source can be also estimated from arrival times of tsunamis. From arrival time data at five tide gauge stations, the tsunami source is estimated as ~600 km long. More tsunami data and detailed bathymetry information around stations are essential for a better estimation.

Four earthquakes with M greater than 9 in the 20th century all occurred around the Pacific Ocean. This was the first instrumentally-recorded M9 earthquake in the Indian Ocean. Was it unexpected? Paleoseismological work by Sieh and his colleagues using corals (e.g. Natawidjaja et al., 2004) indicated that the Sumatra earthquake in 1833 attained M~9 and similar earthquakes repeated at an interval of 230 years. The 2004 earthquake, however, extended from Sumatra through Nicobar and Andaman Islands, where M~8 earthquakes occurred in 1881 and 1941. Paleoseismological work, e.g., using corals, in Sumatra, Nicobar and Andaman Islands would help to reveal the occurrence and recurrence of great earthquakes in prehistoric time. An implication to other subduction zones, such as around Japan, is that if an M 9 earthquake can occur in subduction zones where only M 8 earthquakes have been recorded (and considered as maximum)? Recent paleoseismological studies have indicated that giant (M~9) earthquakes occurred in prehistoric time in Cascadia subduction zone or along the Kuril trench.