

Historic earthquakes test Indonesia's seismic hazard assessment

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Using data gleaned from historical reports, researchers have now identified the sources of some of the most destructive Indonesian earthquakes in Java, Bali and Nusa Tenggara, using these data to independently test how well Indonesia's 2010 and 2017 seismic hazard assessments perform in predicting damaging ground motion.

The study published in the *Bulletin of the Seismological Society of America* concludes that the hazard assessments do well at predicting damaging ground motion in key Javanese cities, but that there is much more to learn about earthquake sources in the region.

Indonesia has made earthquake risk prediction a priority after the magnitude 9.1 Sumatra-Andaman [megathrust](#) earthquake and tsunami in 2004, but to date most of the research on regional earthquake hazard has concentrated on Sumatra, at the expense of studies further east in Java, said Jonathan Griffin of Geoscience Australia and colleagues.

More than 57 percent (about 140 million people) of Indonesia's population lives in Java, "on a relatively small island roughly the same area as New York State, or the North Island of New Zealand, that faces many natural hazards," explained Griffin. "Getting the hazard levels right to underpin building codes is therefore critically important for a huge number of people, particularly combined with rapid economic growth and urbanization in Indonesia."

Probabilistic seismic hazard assessments or PSHA is a method that calculates the likelihood that certain levels of earthquake-related ground shaking will exceed a specific intensity at a given location and time span. PSHA calculations are based on data from earthquakes detected by seismographs, however, so some of the largest and most damaging earthquakes in a region may

not be included in the assessments if they occurred before instrumentation in a region.

Griffin and colleagues analyzed historical catalogs and accounts of earthquakes in Java, Bali and Nusa Tenggara from 1681 to 1877, to determine the source and shaking intensity for some of the region's historically destructive earthquakes.

The most significant tectonic feature of the Indonesian region is the collision and subduction of the Indian and Australian tectonic plates under the Sunda and Burma tectonic plates, generating megathrust earthquakes like the 2004 Sumatra quake. However, the researchers found little evidence for the occurrence of large earthquakes on the Java Megathrust fault during the historic time period they studied.

Instead, they concluded that large intraslab earthquakes (earthquakes that occur within a subducting tectonic plate) were responsible for some of Java's most damaging historic quakes, including a magnitude 7.4 earthquake near Jakarta in 1699 and a magnitude 7.8 quake in Central Java in 1867. The researchers also noted a cluster of large earthquakes occurring on the Flores Thrust to the east of Java in 1815, 1818 and 1820, as well as earthquakes on shallow crustal faults on Java that had not been mapped previously.

The Flores Thrust was responsible for two magnitude 6.9 earthquakes in Lombok in August 2018 that together killed more than 500 people.

Intraslab earthquakes are well-known in the region, including recent events such as the magnitude 7.6 quake in West Sumatra and the magnitude 7.0 quake in West Java that together killed more than 1000 people in 2009, said Griffin. "However we were surprised that we didn't find conclusive evidence for a large megathrust event during the time period we examined."

Although it can be difficult to distinguish between megathrust and intraslab earthquakes using the data analyzed by the researchers, Griffin said that the data he and his team analyzed fit better with an intraslab model. "So while the intraslab models fit the data better for earthquakes in 1699 and 1867, we also rely on an absence of tsunami observations from coastal locations where ground shaking damage was reported to make the case that intraslab events were the more likely source," he added.

"The absence of strong historical evidence for a large megathrust earthquake south of Java over the past 350 years is a really interesting problem," said Griffin. Javanese and Dutch population centers "were historically on the north coast facing the calmer Java Sea, so we only have limited data from the less hospitable south coast. So it's quite likely that smaller megathrust earthquakes have occurred that aren't captured well in the historical records, but we'd be surprised if a really large [earthquake](#) went unnoticed."

Previous research suggests that that the length of time between earthquakes on the Sumatran megathrust varies considerably, said Griffin. "So the lack of large megathrust events south of Java over the past few centuries could just imply that we have been in a period of relative inactivity, but not that large earthquakes occur less frequently here on average over the long-term."

More information: Historical Earthquakes of the Eastern Sunda Arc: Source Mechanisms and Intensity?Based Testing of Indonesia's National Seismic Hazard Assessment, [DOI: 10.1785/0120180085](#) , <https://pubs.geoscienceworld.org/ssa/bssa/article-abstract/567591/historical-earthquakes-of-the-eastern-sunda-arc>

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