

Variations in Modes of Failure along the Sunda Megathrust

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We have characterized the long-term behavior of 900 km of the Sumatran portion of the Sunda megathrust using coral microatolls, GPS, and remote sensing. In addition to coseismic deformation associated with the 2004 and 2005 earthquakes, we have measured interseismic strain accumulation rates and coseismic deformation associated with past historical and prehistoric earthquakes between 3°S and 3°N. We identify four distinct sections of the megathrust along this reach, each with its own apparent mode of strain accumulation and release.

The Mentawai section of the Sunda megathrust, south of 0.5°S, experienced great earthquakes in 1797 and 1833. Uplift in 1797 extended 370 km, between 3.2° and 0.5°S, and was at least as great as 0.8 m. The region of uplift in 1833 ranges from 2° to at least 3.2°S and, judging from historical reports of shaking and tsunamis, perhaps as far as 5°S; uplift in the latter event reached 2.8 m and extended farther downdip than in 1797. Modeling of the uplift associated with these earthquakes yields magnitudes (M_W) in the range 8.7 to 9.1. Over the past millennium, similar episodes of uplift, presumably associated with great earthquakes or earthquake couplets, have occurred about every 230 years.

The Batu Islands section of the megathrust, between 0.5°S and 0.5°N, appears to be a comparatively aseismic section of the fault. The largest rupture of this patch in the past 250 years was a M_W 7.7 earthquake in 1935. During that event, sites closest to the trench rose 90 cm, whereas sites further east sank by as much as 35 cm. The 1797 and 1833 ruptures, to the south, did not propagate through this section, and the great earthquakes of 1861 and 2005 did not propagate through from the north. Thus, the Batu Islands segment has been a persistent barrier to neighboring great ruptures.

The section immediately north of the Batu Islands patch ruptured most recently in the M_W 8.7 earthquake in March 2005 from 0.5°N to central Simeulue at ~2.5°N. Scant historical data that suggest shaking was strongest on the island of Nias, together with an uplifted coral microatoll that was determined by U-Th dating to have died within a few years of A.D. 1861 on the southern half of Simeulue, suggest that the 1861 earthquake was similar, at least in extent, to that in 2005. North of the 1861/2005 Nias-Simeulue patch lies the region of the 2004 earthquake. Our search for uplifted microatolls along the northern coast of Simeulue has just begun, but results thus far suggest that the previous seismic uplifts there occurred much earlier than 1861. Corals uplifted during the 10th and 14th centuries A.D. could be interpreted as an indication that 600 and 400-year dormancies preceded the 2004 event there; however, given that the slip in 2004 was only about 10 m under northern Simeulue, we may well find evidence of younger uplifts.

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