The giant subduction earthquakes of 1797 and 1833, West Sumatra: Characteristic couplets, uncharacteristic slip

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Rupture of a large patch of the Sumatran subduction zone produced a giant earthquake in 1797. Roughly the same patch ruptured again in 1833, just 36 years later. The magnitude of slip in 1833 was several times greater than that in 1797.

Two large earthquakes dominate the historical seismic record of the Sumatran subduction zone south of the Equator. In addition to anecdotal reporting of widespread strong shaking, a few reports of large tsunamis and uplift of the outer-arc islands, about 100 to 120 km northeast of the Sumatran trench, have also survived. We have used growth patterns and U-Th dating of coral microatolls to map in detail the vertical deformation associated with these two earthquakes. The patterns of deformation constrain models of slip on the subduction interface, which dips about 12° northeastward about 25 km below the islands.

Sipora, North Pagai and South Pagai Islands, which span a 160-km length of the outer-arc ridge, have corals that display evidence of uplift during the 1797 earthquake. Uplift ranges from zero to 70 cm, and a distinct northeastward tilt, away from the trench, is apparent. The same islands also have corals that record vertical deformation during the 1833 earthquake. Uplift values during that event range from 100 to 230 cm. As in the case of the 1797 deformation, these corals show a pronounced tilt away from the trench. Corals on neighboring Siberut Island, farther northwest, display no evidence of uplift or submergence during either the 1797 or 1833 earthquake.

Our first models of these data, which assume rectangular elastic dislocations, uniform slip, and rupture almost to the trench, fit the data moderately well. They yield slips of ~3 m for the 1797 event and ~12 m for the 1833 event. Estimated Mw of the two events are about 8.4 and 8.7. For both events, rupture beneath all three islands is required to produce the observed uplift. The northwestern limit of both ruptures must be no more than 40 km northwest of Sipora (the northernmost of the three islands). The southeastern limit of the 1797 rupture is well constrained to beneath the southern part of South Pagai (the southernmost of the three). The southeastern limit of the 1833 rupture is poorly constrained, but extended well beyond South Pagai Island. The downdip limit of rupture in 1833 is appreciably deeper (farther northeast) than that of the 1797 event.

The giant 1797 and 1833 earthquakes involved rupture of the same patch of the subduction interface beneath the islands, but slip extended farther downdip and southeast in 1833. Slip on the patch beneath the islands was also several times larger in the latter

event, far more than could have accumulated in the 36 years between events. Thus it appears that slip magnitudes can vary by a factor of four or so on the same fault patch and that not all accumulated strain need be relieved in a giant earthquake. Paleoseismic evidence indicates that over the past millennium, the islands have risen during giant earthquakes or earthquake couplets about every 230 years. At least three of the episodes appear to have been couplets separated by just a few decades.