[P1-1-1] The Next Giant Sumatran Megathrust Earthquake: From Science to Human Welfare

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My colleagues and I have used continuous and survey-mode GPS measurements, corals and other features to document uplift, submergence and horizontal motions associated with the giant Sumatran megathrust earthquakes of 2004 and 2005. Elastic dislocation models based upon these data show that the two earthquakes resulted from nearly contiguous rupture of about 1900 km of the megathrust – from about 16˚N to the Equator. The amount of slip during the 2004 rupture was up to 25 m offshore Aceh; slip was as high as 12 m under Nias island during the 2005 rupture. Repetitions of such large slips are not likely for the next century or more. Questions remain about the potential for damaging but smaller earthquakes along those portions of the megathrust that failed during the 2004 and 2005 earthquakes. But a far greater threat to Sumatra now is rupture of the megathrust farther south.

The Mentawai section of the Sunda megathrust, south of the Equator, remains unruptured and threatens to produce another giant earthquake within the next few decades. Paleogeodetic and geodetic data show that this section of the megathrust has been locked since its most recent giant earthquakes, in 1797 and 1833. Living coral microatolls show that the chain of outer-arc islands above this locked section is submerging at rates as high as a centimeter per year. Continuous GPS measurements show the islands are being squeezed toward the mainland at about 5 cm/yr. Modeling of these strains shows that these reflect elastic strains that will be relieved during future earthquakes.

Paleoseismic records of uplift during the tsunamigenic earthquakes of 1797 and 1833 reveal patterns of uplift and tilt very similar to those that occurred during the 2004 and 2005 earthquakes to the north. The 1797 event involved rupture of the megathrust from about 0.5˚ to 3.2˚ S and had a magnitude (M_w) of about 8.4. The 1833 event was caused by rupture of the megathrust from about 2.0˚ to 5.5˚ S and had a magnitude of about 8.9. Paleoseismic records also show that this 600-km-long Mentawai section of the megathrust ruptures about every two centuries; thus it appears to be nearing the end of the strain-accumulation part of the current earthquake cycle.

There are a number of scientific activities that could and will be undertaken to forecast better the nature of the coming Mentawai earthquake and tsunami. These include work aimed at continuing to measure strain accumulation rates and patterns, refining estimates of the locked parts of the megathrust, searching for precursory changes in strain accumulation or relief, and better documentation of the past one or two thousand years of rupture and tsunami effects there.

But activities that lead directly to mitigation of the destructive effects of future Mentawai earthquakes and tsunamis are desperately needed. If done expeditiously, efforts to educate the populations at risk, to make permanent changes in the infrastructure of coastal communities, and to prepare for emergency response after the inevitable events could have a significant impact in relieving human suffering and reducing loss of life. West Sumatra appears to be a crucible in which humankind is destined to test its ability and resolve to take a new approach to how it addresses natural hazards.