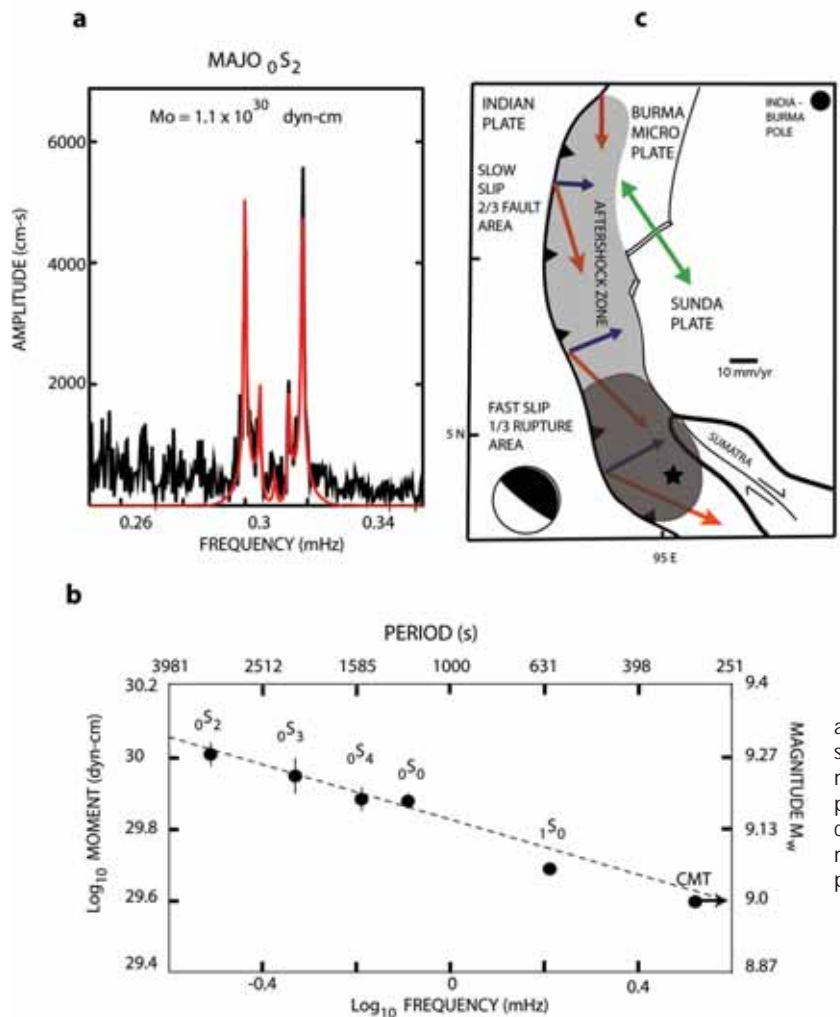


Ultra-long-period Characteristics of the December 2004 Sumatra Earthquake

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What we are learning about the recent December 26, 2004, Sumatra earthquake has important implications for understanding the subduction process, for both scientific and hazard mitigation purposes. Analysis of long period normal modes from IRIS GSN data shows that the earthquake was even bigger than first appeared. The earth's longest period normal mode, ${}_0S_2$, shows a seismic moment of 1.1×10^{30} dyn-cm, or moment magnitude $M_w = 9.3$, approximately 2.5 times larger than initially reported, making the earthquake the second largest ever instrumentally recorded. The larger magnitude likely reflects slip along the entire rupture zone suggested by aftershocks, a much larger area than previously inferred, which is comparable to a rupture of most of the Cascadia subduction zone. These observations have various important implications. It is the first time we have observed seismic moment systematically increasing with period at such long periods. Hence methods normally used to assess earthquake size dramatically underestimate it. This has not been previously observed, raising important issues about



the physics of faulting, notably at what period the moment stabilizes. Although this issue will be difficult to resolve for Sumatra, it illustrates the need to integrate seismology with GPS. Another surprising implication for tsunami physics is that the tsunami observations are in accord with our model in which the entire fault rupture contributed to the tsunami, raising the question of how slow slip could do so. Finally, the larger area indicates that strain on the entire rupture zone has been released, leaving no immediate danger of a comparable tsunami being generated on this part of the plate boundary. This rupture zone is larger than observed in earlier earthquakes along this boundary segment, indicating the variable mode of subduction zone rupture.

a, Observed (black) and predicted (red) amplitude spectrum for a ${}_0S_2$ multiplet, showing best-fitting seismic moment. b, Variation in seismic moment and M_w with period. "CMT" denotes result from 300-s surface waves. c. Schematic illustration comparing aftershock zone to minimum area of fast slip estimated from body waves and possible area of slow slip inferred from normal modes.

S. Stein and E. A. Okal, Speed and size of the Sumatra earthquake, *Nature*, 434, 581-582, 2005.