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On September 12, 2007, the Mw8.4 South Pagai earthquakes ruptured the subduction interface offshore southern Sumatra. The earthquake occurred within the area monitored by the Sumatra Geodetic Array (SuGAr). The cGPS stations on South Pagai Island show about 1.5 m of southwestward displacement, up to 0.6 m of uplift of the western coast of the island, and 0.1 m of subsidence of the eastern coast. Coastal stations near Bengkulu show about 70 cm southwest motion. We have obtained a finite-fault source model of the earthquake from the inversion of co-seismic displacements measured at 13 near-field cGPS stations from the SUGAR network together with the teleseismic waveforms measured at 35 stations. In addition, the model geometry was checked and adjusted by comparing observed and predicted long period surface waves and normal modes. The source is a northward unilateral rupture with two main asperities, a deeper one, extending relatively deep beneath Bengkulu coastal area and a shallower one beneath South Pagai. Co-seismic slip reached a maximum of about 5.5 meters under South Pagai. The earthquake was not very impulsive with rise times of the order 10 seconds and a rupture velocity of about 2 km/s. The rupture initiated at the southeastern edge of a patch of the subduction interface that had been shown to be strongly locked from geodetic and paleogeodetic interseismic measurements. The rupture propagated unilaterally to the north rupturing only a fraction of a strongly coupled fault patch. The previous large earthquake on that portion of the megathrust was a M8.6 event in 1833 which produced much larger co-seismic uplift. The 2007 event released only a small fraction of the deficit of moment that has accumulated since then due to interseismic locking of the subduction interface.