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Rupture zone of the Mw=8.8 2010 Maule earthquake constrained by aftershock seismicity and teleseismic moment tensor inversion of large aftershocks

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On 27 February 2010, a Mw=8.8 earthquake occurred in south central Chile to the north of the Great Mw=9.5 Valdivia earthquake of 1960, hitting the Chilean Maule and Bio-Bio districts, including the towns of Concepción and Constitución. Rupture spread bilaterally, affecting a 500-600 km long portion of the Chilean margin between the Arauco Peninsula and Valparaíso and hence spread into the nucleation area of the Valdivia earthquake and re-ruptured the Talca segment that broke last in 1928. Here we use constraints from aftershocks to survey the rupture area of the Maule earthquake, including first results from a 3 month deployment of 30 ocean-bottom-seismometers recording local aftershocks offshore of the Maule district between 20 September 2010 and 25 December 2011. Seaward co-seismic rupture, approximated by the aftershock distribution, stopped about 20-40 km landward of the trench in an area characterised by water-rich sediments and temperatures of 100°-150°C and hence velocity strengthening aseismic behaviour. Teleseismic waveform inversion of body-waves from large aftershocks was used to provide additional constraint on the geometry of the rupture zone. Large events (Mw>5.8) with thrust mechanisms associated with the rupture zone occurred under the shelf break at 20 km depth, near the epicentre of the mainshock at a depth of 27 km, and near the down-dip limit of the seismogenic zone at 49 km depth. The two largest aftershocks of Mw=6.9 and 7.0, however, occurred near the town of Pichilemu in the upper plate. Mechanisms and aftershock distribution indicates a major tensional upper plate fault system, striking at ∼145°-155°. The fact that the clustered activity occurred above a major slip patch of the mainshock may suggest that aftershocks were triggered by static stress changes caused by the mainshock. Shallow normal faulting activity occurred seaward of the trench, indicating that unlocking of the seismogenic zone transferred stresses into the trench-outer rise.