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Observed seismicity and models of postseismic stress relaxation offshore SW Iberia

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The region offshore SW Iberia is dominated by low to moderate magnitude events (Mw $\leq$ 6.0), although large and destructive earthquakes such as the 1969 earthquake have nucleated here. An important part of the instrumental seismicity occurs beneath the Horseshoe Abyssal Plain, within the probable source area of the 1755 Lisbon earthquake and tsunami. Fault slip rates, based on thin-sheet neotectonic models, are estimated to be in the range of 1 to 2 mm/yr. These values are in agreement with low rates of tectonic loading inferred from geological data onshore western Iberia and support predictions of long recurrence intervals (> 3000 yr) for large magnitude (Mw > 8) earthquakes. Available focal mechanisms show reverse and strike–slip fault plane solutions that are compatible with NW–SE to NNW–SSE shortening, accommodated along NE–SW trending thrust faults and WNW–ESE dextral strike-slip faults. However, a direct correlation between earthquake locations and known major active faults is not straightforward, because most present-day earthquakes occur in the lithospheric mantle at 40–60 km depth while faults are only imaged at upper crustal levels. This study seeks an explanation for the nucleation of low magnitude local earthquakes recorded beneath the Horseshoe Abyssal Plain at depths exceeding 40 km. We hypothesize that elevated postseismic strain rates and stresses in the upper mantle may last long enough to trigger low magnitude events during the interseismic period of major earthquakes. The coseismic and postseismic changes in the state of stress near the lower tip of a thrust fault is investigated using a two-dimensional finite element model with a frictional-power law rheology. Results demonstrate that a major displacement event can cause very large differential stress and creep strain rates at the lower termination of the fault, producing a deflection of the brittle-ductile transition zone, and a zone of elevated strain rates at depth. The deflection of the brittle-ductile transition and the timescale of the postseismic stress relaxation in the upper mantle is a complex function of material properties and temperature, as well as of stress and strain rate. This study presents the results of an extensive set of parameter sensitivity tests that constrain the combination of rheologic conditions that are compatible with the small earthquake observations in the Horseshoe Abyssal Plain.