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Seismic and aseismic slip on the central Peru megathrust

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In the last couple of decades, advances in the analysis techniques and instrumentation have improved significantly our capability to document the different stages of the seismic cycle, namely the co-, post- and inter-seismic phases. To this respect, the Mw8.0 Pisco, Peru, earthquake of August 2007 is exemplary, with numerous data sets allowing exploring the details of each phase and studying their relationship. The post-seismic deformation following the mainshock is studied using a local network of continuous GPS stations together with various InSAR interferograms. Inversion for slip on the fault is carried on using the PCAIM inversion method (http://www.tectonics.caltech.edu/resources/pcaim/). The inversion shows two patches of significant afterslip located near the co-seismic asperities, in agreement with the idea that coseismic slip triggers afterslip. Aftershocks are located on top of the patches of high postseismic slip, while they are anti-correlated with the position of the co-seismic asperities, consistent with the idea that afterslip drive aftershocks. Post-seismic relaxation is consistent with rate and state friction, assuming a rate strengthening rheology. The most prominent of those post-seismic patches coincides with the subducting Nazca ridge, an area also characterized by a locally low interseismic coupling and which seems to have acted as a barrier to seismic rupture propagation repeatedly in the past. The 'seismogenic' portion of the megathrust thus appears to be paved with interfingering of rate-weakening and rate-strengthening patches. The rate-strengthening patches are shown to contribute to an unsuspected high proportion of aseismic slip and to determine the extent and frequency of large interplate earthquakes. Aseismic slip accounts for as much as 50-70% of the slip budget on the seismogenic portion of the megathrust of central Peru and the return period of Mw 8.0 earthquakes in the Pisco area is estimated to 250 years, a value in good agreement with the 261 years between the 2007 Pisco earthquake and the previous large megathrust earthquake in this area which occurred in 1746.