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The role of fluids on the seismogenic behaviour of the Maule (central Chile) megathrust: afterslip, aftershock and long-term structure

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Analyzes of geodetic and seismologic observations during the different phases of the seismic cycle are consistently showing that the fault interface is highly heterogeneous in terms of the spatial distribution of its frictional properties. For example, inversion of geodetically-determined deformation produced by great subduction earthquakes demonstrates that co-seismic slip propagates by rupturing different patches of the megathrust and that heterogeneous landward movement of GPS sites during the interseismic phase can be matched after assuming a spatially variable distribution of fault locking. Into this context, some key questions regarding the nature and temporal persistence of this heterogeneous fault structure remain open. For instance, do coseismic asperities (patches of large slip during an earthquake) always coincide with the location of interseismic asperities (patches of high fault locking)? Can both be characterized by the same frictional properties? Are asperities a transient features that change its position from one earthquake to the other or, by the contrary, its location is permanent and determined by the long-term structure of the subduction zone? We aim to answer some of these questions comparing the spatio-temporal behavior of aftershocks and afterslip recorded during the first one and a half year of postseismic geodetic deformation and seismicity following the Mw8.8 2010 Maule earthquake. Afterslip at the megathrust has been computed inverting surface deformation observed by a dense network of continuous GPS stations. We used the NEIC catalog to compute the b-value that characterizes the frequency-magnitude distribution of seismicity for a number of time-windows. We created maps and time-series for both parameters showing that: 1) the area around the southern coseismic asperity has low b-values and very small afterslip during the observation period, both suggestive of rapid healing and re-locking of the megathrust, 2) afterslip starts propagating from the epicentral region coincidentally with a gradual decrease in seismicity at intermediate b-values, 3) there is a northward migration of high b-values and high afterslip toward the northern coseismic asperity, likely indicating the migration of fluids at the megathrust. The contrasting postseismic behavior inferred along the strike of the coseismically-ruptured megathrust segment partially resembles the preseismic distribution of fault locking and b-value. This suggests that features of the megathrust presumably linked to frictional properties at the fault are spatially controlling the three phases of the seismic cycle. Moreover, the inferred spatial variations of these properties are also partially correlated with the long-term geological structure of the forearc, as inferred by an analysis of gravity anomalies. Our results indicates that the distribution of frictional properties at the megathrust seems to be spatially persistent and linked to long-term features of the forearc, although during each phase of the seismic cycle they can transiently change