Appendix A. Bulk Rock Strength Significantly Affecting the Spatial Distribution of Seismicity

To explore the effect of different and realistic pore fluid pressures in model materials, the pore fluid pressure factor $\lambda$ is lowered from 0.6 to 0.4 in non-sedimentary crustal rocks (Fig. A.1). The static friction coefficient $\mu_{\text{eff}}$ is thus increased from 0.24 to 0.36 in the internal part of the Apennines (the metamorphic Tuscan units) and in the Adriatic continental basement. This reduces the rate of seismicity in both the extensional and the compressional upper crustal regimes. In particular, the overall seismic rate in the extensional regime is decreased by almost 60% and its lateral extent of seismicity is limited to the crest area. However, the total $M_0$ released changes very little (Fig. A.1). In other words, greater strength of the internal part of the range results in seismogenic yielding in the extensional regime being focused on larger, less frequent ruptures. In the compressional crustal regime, instead, the $M_0$ released is halved as a result of the Adriatic basement being stronger. Conversely, the seismic rate there increases by $\sim 20\%$.

Uniformly applying the same low friction ($\mu_s = 0.6, \lambda = 0.6, \text{static } \mu_{\text{eff}} = 0.24$) used for sediments to all rock types greatly increases (more than five-fold) the total $M_0$ released in the bending lithospheric mantle. The seismic moment released in both the extensional and compressional regime of the crust is instead decreased (by around 50% and 30%). At the same time, the greater propensity for failure increases the depth extent of seismogenic faults in the compressional regime to around 25 km, into the basement. Meanwhile, average upper crustal stresses change very little. Conversely, the maximum normal and shear stresses in the bending slab hinge (averaged vertically at 35–60 km depth and throughout the short-term model phase) decrease by around 30%.

Using a uniform, higher friction ($\mu_s = 1.5, \lambda = 0.6, \text{static } \mu_{\text{eff}} = 0.6$) for all rocks reduces yielding throughout the model. Therefore, the seismic moment released decreases in all tectonic regimes. However, the decrease is largest in the compressional domain, where only $\sim 20\%$ of the seismic moment is released (compared with the same domain in the reference model). However, seismic rates do not follow the
relative decreases occurring in seismic moment. In fact, the proportion of seismic moment released in each interval of moment magnitude is significantly altered. The decrease in seismic moment released in the compressional regime is due to the disappearance of the largest earthquakes (with moment magnitude $M_W \geq 6.5$), while the overall seismic rate over all magnitude values is hardly affected. Conversely, the small decrease in moment magnitude in the extensional regime takes place by a decrease in the number of small earthquakes in the mountain range, which halves the overall seismic rate in that regime.

Appendix B. Fault Friction Asymmetrically Affecting the Tectonic Deformation Pattern

Fault friction has a significant effect on surface velocities and, to an even greater extent, on earthquake locations. Decreasing friction slightly raises the amplitude of the broad peak in horizontal velocities from $\sim 1.5 \text{ mm yr}^{-1}$ for $\mu_s = 0.3$ to $\sim 2 \text{ mm yr}^{-1}$ for $\mu_s = 0.2$. The rate of both external range extension and buried thrust belt shortening thus increases. The amplitude of the peak in subsidence rates is raised from $\sim 4$ to $\sim 5 \text{ mm yr}^{-1}$. Reducing fault friction also increases the cumulative $M_0$ release in the compressional

Figure A.1: Comparison of the total seismic moment $M_0$ (above) and number of earthquakes (below) in models with different bulk rock $\mu_s$ (and thus strength). The two crustal regimes and the lithospheric mantle slab are selected manually and considered separately. The two crustal regimes and the lithospheric mantle slab are selected manually. Only earthquakes with $M_W \geq 3.5$ are considered.
regime, while decreasing it in the extensional one (Fig. B.2). Seismic rates show a similar change. In other terms, the lateral distribution of seismicity, in terms of both event frequency and moment release, is strongly affected. Activity moves away from the mountain range and towards the active thrust belt. Conversely, increasing $\mu_s$ from 0.3 to 0.4 similarly decreases the total $M_0$ released in both crustal regimes. The value of 0.3 for $\mu_s$ in a model with the reference parameters and temperatures thus seems to be close to an optimum. In fact, it maximizes the focusing of seismogenic rupturing in the range while minimizing it in the two other tectonic regimes, where $\sigma_{II}'$ is higher. This behavior shows that the following two opposing mechanisms both shift seismicity towards the areas with the highest stresses and can act in the same model and: one hand, increasing fault yielding because of lower friction; on the other, increased seismogenic yielding due to locally higher stresses caused by higher friction.

Figure B.2: Comparison of the total seismic moment $M_0$ in models with different friction $\mu$ (and constant $\lambda = 0.6$) on faults. The isotherms corresponding to the different temperature setups used are shown in ???. Increasing slab pull increases the seismic moment released in both the extensional and compressional regimes of the upper crust. The two crustal regimes and the lithospheric mantle slab are selected manually. Only earthquakes with $M_w \geq 3.5$ are considered.

Appendix C. Additional figures
Figure C.3: Average interseismic vertical velocities (positive upwards) at the surface of models with different temperatures in the slab and its surroundings (Fig. 3).

Figure C.4: Average interseismic vertical velocities (positive upwards) at the surface of models with different values of the shear modulus $G$ of the lithospheric mantle.