## SETUP OF THE FINITE-ELEMENT MODEL

The finite-element models were created with the software ABAQUS and consist of a 100-km-thick lithosphere, which is subdivided into a 15-km-thick elastic upper crust, a viscoelastic lower crust (15 km thick), and a viscoelastic lithospheric mantle (Fig. DR1). In our reference model, we use a linear viscosity of $10^{20}$ Pa s for the lower crust. Additional models were computed with viscosities of $10^{18}$, $10^{19}$, and $10^{21}$ Pa s, respectively. We do not apply a strain-rate dependent viscosity to keep the models computationally feasible. In the upper crust, a 40-km-long fault is embedded (Fig. DR1), which is modeled as a contact interface between the fault footwall and hanging wall. Slip does not extend beyond the 40-km-wide fault plane. The fault dip is 60° in the normal fault model and 30° in the thrust fault model. Note that our model fault represents an intra-continental dip-slip fault and is not designed for application to the plate interface in subduction zones. Slip on the model fault is controlled by a Mohr-Coulomb criterion $\tau = C + \mu\sigma_n$, where $\tau$ is the shear stress, C cohesion, $\mu$ the friction coefficient and $\sigma_n$ the normal stress. In our models, we use a friction coefficient of $\mu = 0.4$ and zero cohesion in the model phases during which the fault accumulates slip (explained below).

Each model run consists of a sequence of quasi-static analysis steps and starts with the establishment of isostatic equilibrium. Afterwards, slip on the fault is initiated by extending or shortening of the model at a rate of v = 6 mm/a (Fig. DR1). At this stage, the fault slips continuously and its slip rate, which we do not prescribe, increases gradually until it reaches a constant value. When the fault has reached a constant, steady-state slip rate (measured at the fault center on the model surface), we lock the fault, i.e. further slip is prohibited, while the far-field shortening or extension continues. We prescribe the length of the locked phase such that the 40-km-long fault experiences a maximum coseismic displacement of 2 m at the fault center during the next model step, which represents the coseismic phase. A coseismic displacement of 2 m reflects the amount of slip typical of a $M_w \approx 7$ earthquake on a 40-km-long fault. To simulate the earthquake, we change the boundary condition on the fault from locked to unlocked, which enables sudden slip on the fault plane owing to the strain that was built up during the preceding locked phase. In all models, the coseismic phase is prescribed to be 30 s long and most of the slip occurs during the first half of the coseismic phase. The friction coefficient during the coseismic phase is the same as during the analysis step with continuous fault slip ($\mu = 0.4$). At the beginning of the subsequent postseismic phase, we lock the fault again while shortening or extension of the model continues. Postseismic afterslip on the fault plane is not considered in our models.

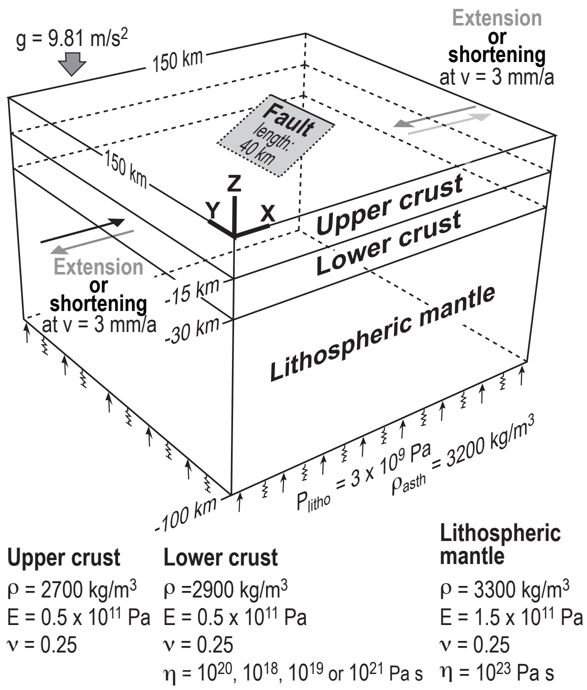


**Figure DR1.** Perspective view of the model lithosphere. The size of the model was chosen such that the results are not affected by the model boundaries. The rheological parameters are density ($\rho$), Young's modulus (E), Poisson's ratio ($\nu$) and viscosity ($\eta$). In the upper crust, a 40-km-long fault is embedded, whose dip is 60° in the normal fault model and 30° in the thrust fault model. Slip on the fault is initiated by extension or shortening of the model at a total rate of v = 6 mm/a. In our models, we use a friction coefficient of $\mu = 0.4$ and zero cohesion in the analysis steps with an unlocked fault (see text for details). Gravity is included as a body force. Isostasy is implemented by adding a lithostatic pressure ($P_{litho}$; black arrows) and an elastic foundation (springs), whose property represents the density of the asthenosphere ($\rho_{asth}$), to the bottom of the model, which is free to move in the vertical and the horizontal directions; model sides in the xz-plane are fixed in the y-direction.

## Figure DR 2

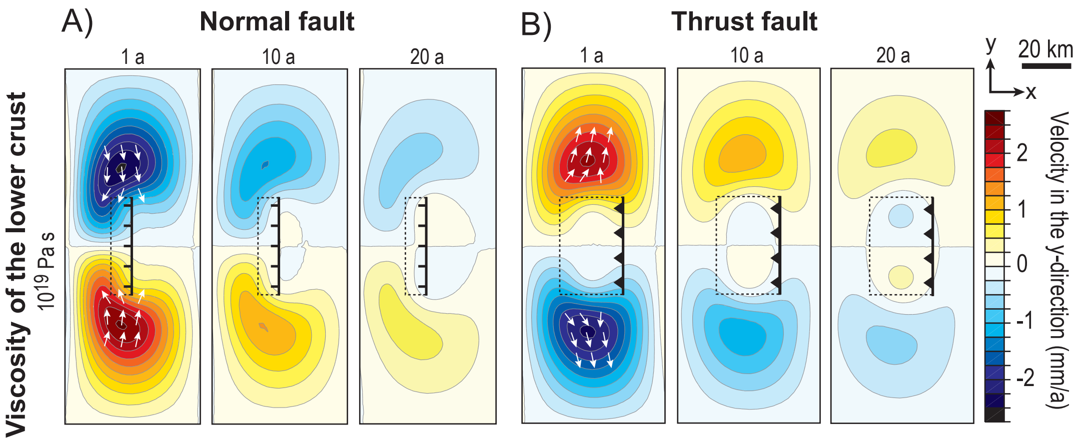


**Figure DR2.** Postseismic evolution of the fault-parallel surface velocity field for a viscosity of the lower crust of $10^{19}$ Pa s. A: Normal fault model. B: Thrust fault model. All velocities are averaged over a period of 1 a, e.g., the velocity at 10 a after the earthquake is the average over the time interval from 9 to 10 a. White arrows indicate the direction of the total horizontal movement beyond the fault tips where fault-parallel motion exceeds fault-perpendicular motion.

## Figure DR 3

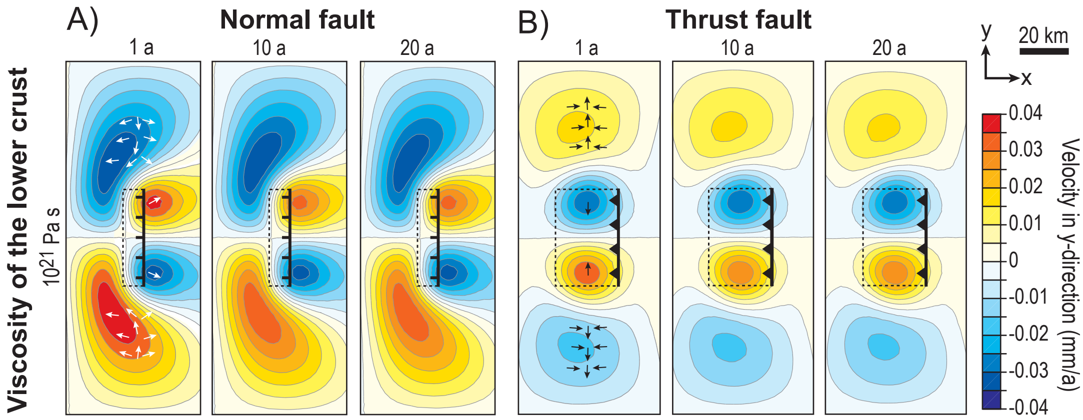


**Figure DR3.** Postseismic evolution of the fault-parallel surface velocity field for a viscosity of the lower crust of $10^{21}$ Pa s. A: Normal fault model. B: Thrust fault model. All velocities are averaged over a period of 1 a, e.g., the velocity at 10 a after the earthquake is the average over the time interval from 9 to 10 a. Arrows indicate the direction of the total horizontal movement beyond the fault tips where fault-parallel motion exceeds fault-perpendicular motion.

# Figure DR 4

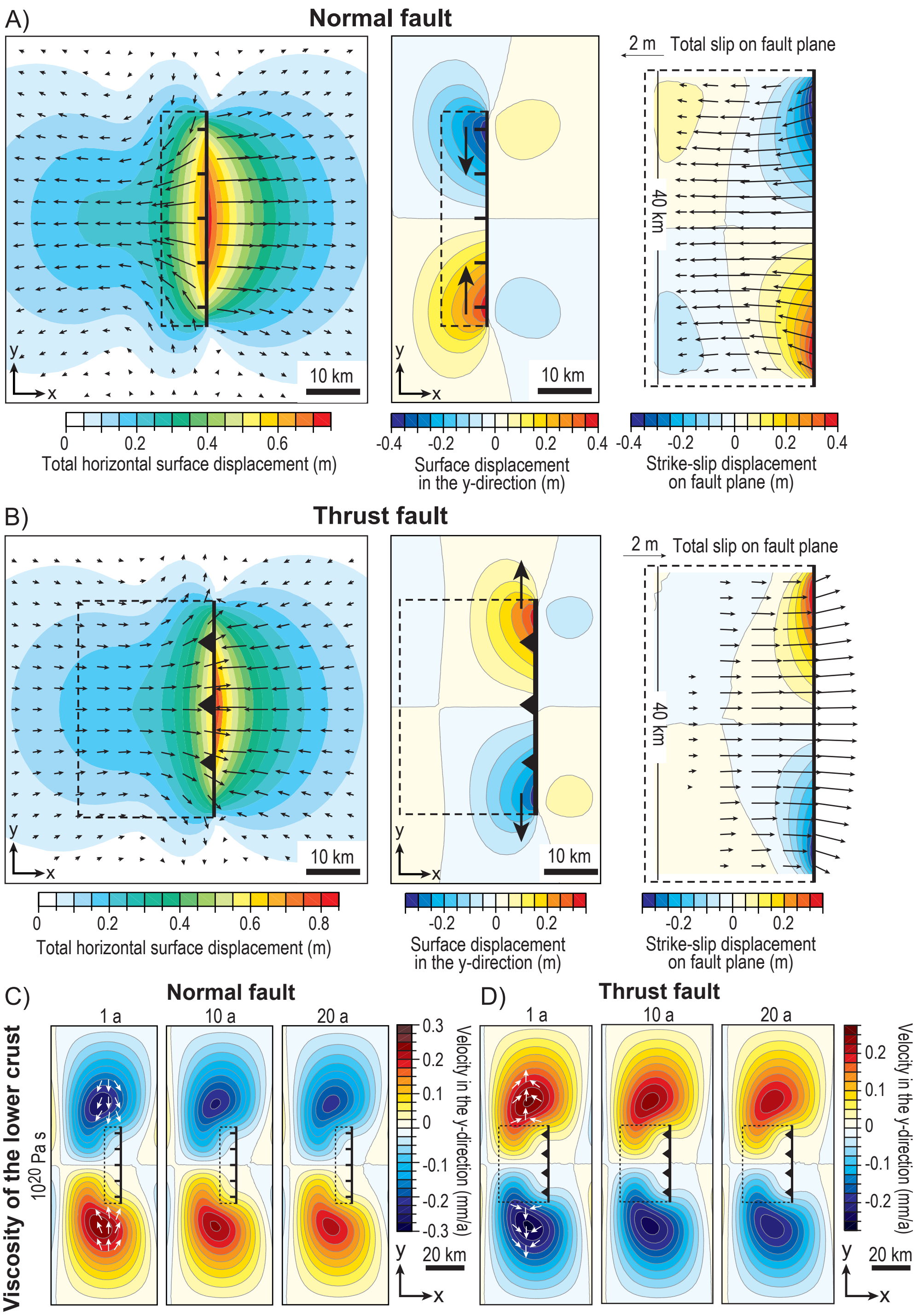


**Figure DR4.** Results for a 45°-dipping model fault. (A, B): Coseismic total horizontal surface displacement, fault-parallel surface displacement, and strike-slip displacement on the fault plane in (A) the normal fault model and (B) the thrust fault model with a viscosity of the lower crust of $10^{20}$ Pa s. In the left column, the total horizontal surface displacement is shown by color coding as well as displacement vectors. In the right column, the color code refers to the strike-slip on the fault plane, while the vectors show the total slip on the fault plane (maximum dip slip in the fault center: 2 m). (C, D): Postseismic evolution of the fault-parallel surface velocity field for a viscosity of the lower crust of $10^{20}$ Pa s. C: Normal fault model. D: Thrust fault model. All velocities are averaged over a period of 1 a, e.g., the velocity at 10 a after the earthquake is the average over the time interval from 9 to 10 a.White arrows indicate the direction of the total horizontal movement beyond the fault tips where fault-parallel motion exceeds fault-perpendicular motion.

# Figure DR 5

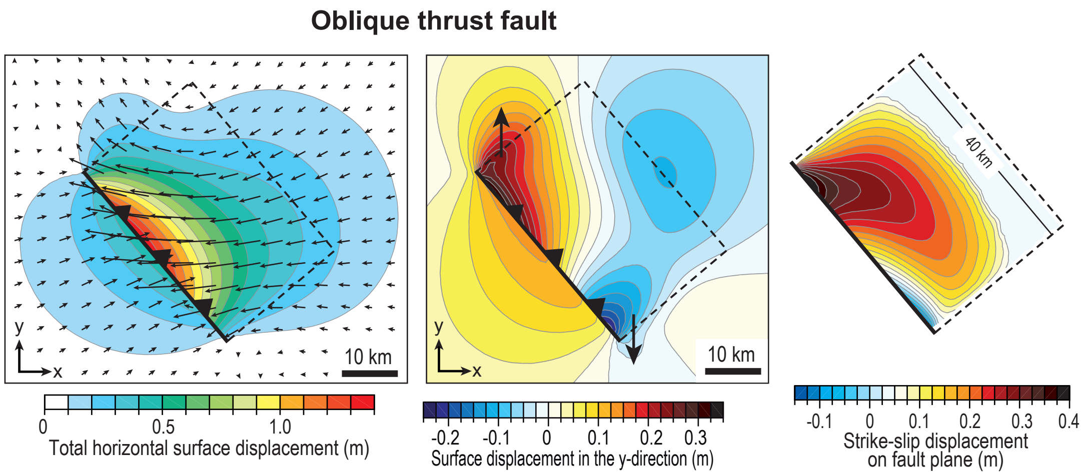


**Figure DR5.** Coseismic total horizontal surface displacement, surface displacement in the y-direction, and strike-slip displacement on the fault plane in an oblique thrust fault model with a viscosity of the lower crust of $10^{20}$ Pa s. The angle between fault strike and shortening direction is 50°. The dip-slip displacement on the fault plane is 2 m at the model surface. The total horizontal surface displacement is shown by color coding as well as displacement vectors.