DATA REPOSITORY ITEM 2009099 **Rey et al.**

Supplementary Information:

Our starting model is a 270 km long and 90 km thick box that includes 15 km of air-like material (low density, low viscosity) and a 60 km thick crust above 15 km of upper mantle. The conductive geotherm is allowed to thermally equilibrate until the Moho reaches 975ºC, which results in a large volume of migmatite in the lower crust. Free boundary slip is imposed at the base and the top of the model. The density in crust decreases with the melt fraction (cf. text) but is otherwise temperature independent. In the mantle, we assume of coefficient of thermal expansion of $2.8 \cdot 10^{-5}$. The geotherm is based on a constant heat flow imposed at the base of the model (0.022 $W.m^{-2}$), a constant temperature imposed at the top (20ºC), a depth independent radiogenic heat production in the crust ($7.67 \cdot 10^{-7}$ $W.m^{-3}$) and zero heat flow across the lateral sides of the model. For all rocks we assume a heat capacity of 1000 J kg^{-1} K^{-1} and thermal diffusivity of $0.9 \cdot 10^{-6}$ $m^2.s^{-1}$. A latent heat of fusion of 250 kJ kg^{-1} K^{-1} is embedded into the energy equation. The crust and the mantle have a visco-plastic rheology with a temperature and stress dependent viscosity for stresses below the yield stress, and a depth dependent plastic branch above it to simulate frictional flow. In the crust and the mantle, frictional sliding is modeled via a Mohr Coulomb criterion with a cohesion (C_0) of 15 MPa and a coefficient of friction (m) of 0.44. The cohesion and coefficient of internal friction in the detachment fault is C_0 /10 and m/10. In all material, the yield stress linearly drops to a maximum of 20% of its initial value when the accumulated strain reaches 0.5. For differential stresses that attain the yield stress, the material fails and deformation is modeled by an effective viscosity: $\eta_{yield} = \frac{\tau_{yield}}{2E}$ in which E is the second invariant of the strain rate tensor. Power law creep parameters (Brace and Kohlstedt, 1995; Goetze, 1978) are: for crustal quartz-rich rocks (pre-exponent A_c=5 10^{-6} MPa^{-n} s^{-1}, n_c=3, Q_c=1.9 10^5 J mol^{-1}) with a pre-exponent of $10{\cdot}A_c$ for the fault, mantle dry olivine (pre-exponent A_m=7 10^4 MPa^{-n} s^{-1}, n_m=3, Q_m=5.2 10^5 J mol^{-1}). We applied a minimum and maximum viscosity cap of 5 10^{18} s^{-1} and 5 10^{23} s^{-1} respectively.

References Cited

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Goetze, C., 1978, The mechanisms of creep in olivine: Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, v. 288, p. 99–119, doi: 10.1098/rsta.1978.0008.