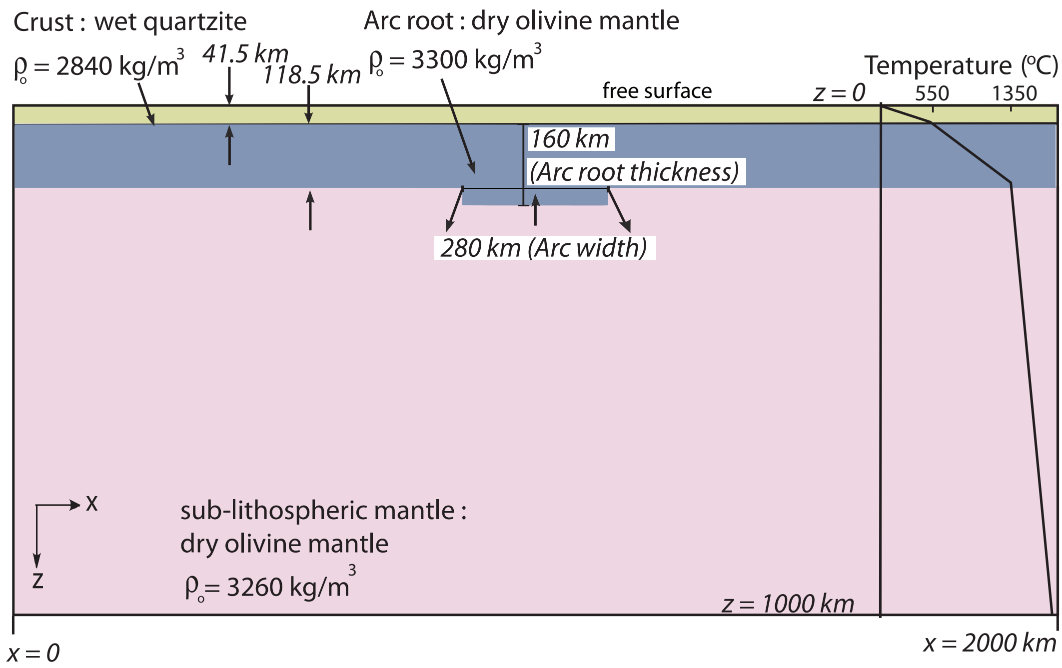
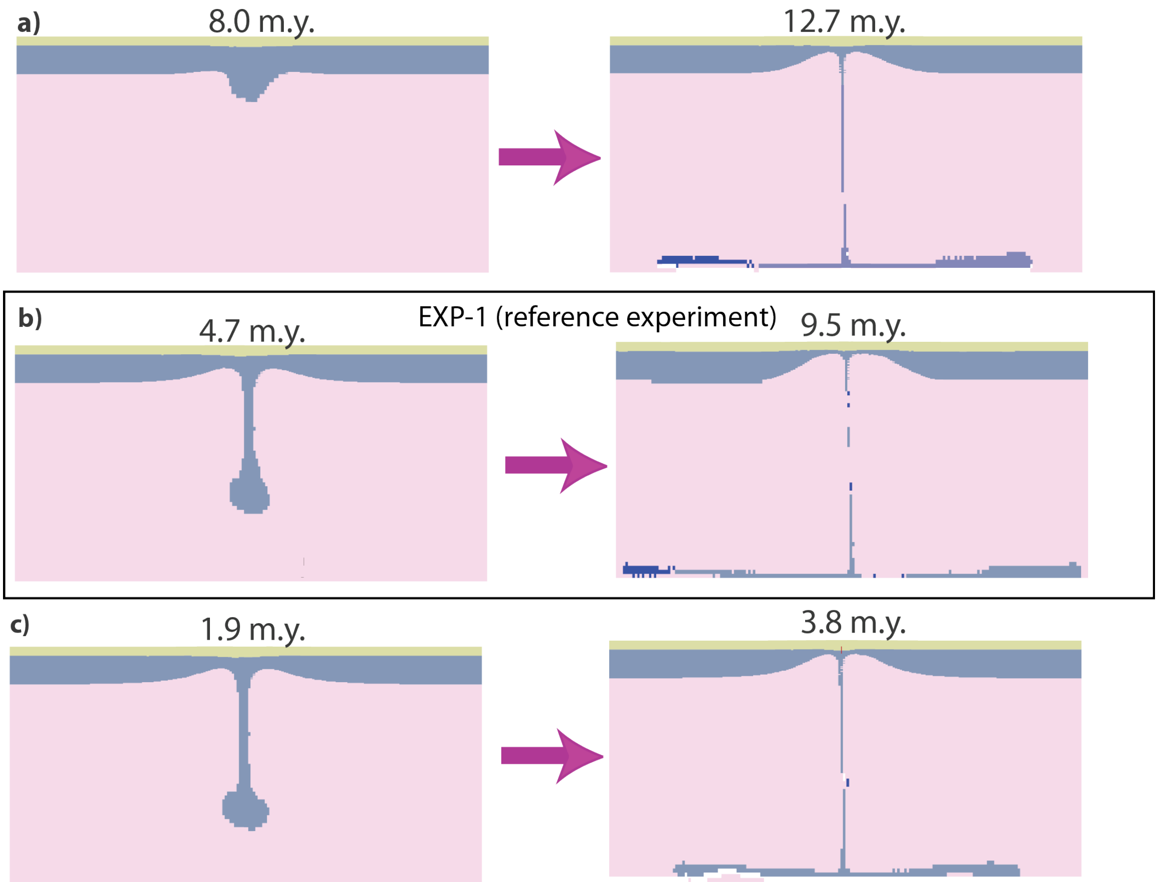


Supplementary Figure 1: Illustration of the model geometry, set-up, material properties, and density field for the preferred drip model experiment (EXP-1). In the models, the 160 km thick lithosphere is made up of 41.5 km thick crust (ρ_o= 2840 kg m^{-3}, yellow) and 118.5 km thick mantle lithosphere (ρ_o = 3300 kg m^{-3}, blue) overlying an sub-lithospheric mantle region (ρ_o = 3260 kg m^{-3}, pink). The width (280 km) and the thickness (160 km) of the arc root instability are based on geological, Görür et al [1] and paleomagnetic studies on the Late Cretecaus granitoids of Central Anatolia by Lefebvre et al. [2]. Initial crustal thickness beneath the arc (41.5 km) is based on the estimates from P-wave derived seismic Moho under the Costa Rica- Central American arc ~ 70 Myrs old Gazel et al. [3] and the approximate crustal thickness under Kohistan and Talkeetna arcs Jagoutz and Behn [4]. The 160 km thick lithosphere over the model domain is based on the Late Cretaceous Sierra Nevada arc as base of the sub-batholith mantle lithosphere (e.g., including peridodite and mantle wedge) is at ~ 140 km depth inferred by Saleeby et al [5], as an approximation to the late Cretaceous Central Anatolia-Kırşehir arc. Similarly, a 120 to 150 km boundary for the base of the lithosphere in the Cordilleran arc system (e.g., Altiplano) was suggested by Heit et al [6].

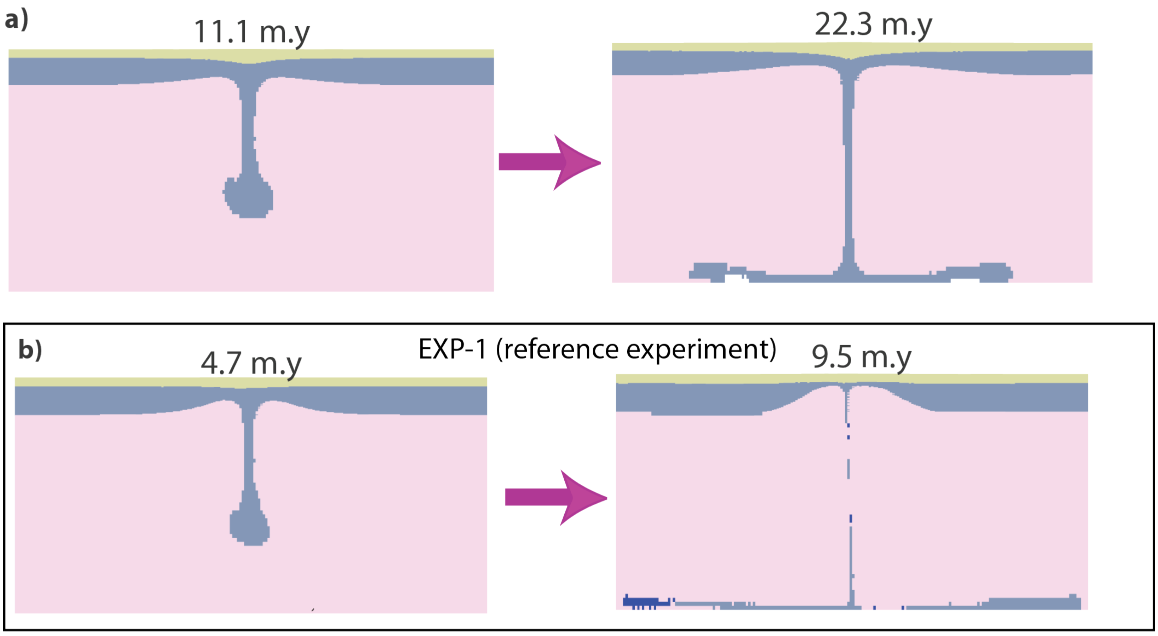
	Parameter	Continental Crust	Mantle lithosphere (Arc root and elsewhere in the model)	Sub-lithospheric mantle (Asthenosphere)
A	Viscosity parameter	$1.1 \times 10^{28} Pa^{-4} s^{-1}$	$10^{-38} Pa^{-n} s^{-1}$	$4.89 \times 10^{-17} Pa^{-3.5} s^{-1}$
n	Power exponent	4.0	3.5	3.5
Q	Activation energy	223 kJ mol^{-1}	0	535 kJ mol^{-1}
ϕ	Effective Internal Angle of friction	15°-2°	0	0
ρ_o	Reference Density	2840 kg m^{-3}	3300 kg m^{-3}	3260 kg m^{-3}
σ_y	Plastic yield stress	1 MPa	0	0
α	Coefficient of thermal expansion	$2.0 \times 10^{-5} K^{-1}$	$2.0 \times 10^{-5} K^{-1}$	$2.0 \times 10^{-5} K^{-1}$

Supplementary Table 1: **Rheological parameters for the preferred numerical experiment (EXP-1)**

Please see methods section for the references of other model parameters (e.g density, internal angle of friction). Note that the mantle lithosphere in EXP-1, EXP-3 and EXP -4 is associated with temperature-independent rheology (Q = 0) but the rheological parameters for the underlying sub-lithospheric mantle (dry olivine mantle) is based on the experimental results from Hirth and Kohlstedt [7] ($A = 4.89 \times 10^{-17} Pa^{-3.5} s^{-1}$, 535 kJ mol^{-1}). For EXP-2 with temperature dependent mantle lithosphere rheology all mantle layers are based on the Hirth and Kohlstedt [7]. The material parameters for the wet quartzite crust are from Gleason and Tullis [8].



Supplementary Figure 2: Comparison of the geodynamic evolution between dripping lithosphere experiments in which density difference between the sub-arc mantle lithosphere (arc root, blue region) is investigated *(*$\Delta\rho = \rho_{arcroot} - \rho_{asthenosphere}$*)*. The reference experiment (EXP-1) with $\Delta\rho = 40$ kg m^{-3} is shown in; b) middle and the one a) above is $\Delta\rho = 30$ kg m^{-3}, whereas the the one below; c) shows $\Delta\rho = 60$ kg m^{-3}. All other model parameters are kept same. Note that such a density difference in EXP-1 is in good agreement with the dynamics of the lithospheric removal and the observed surface uplift of 1 km that occured 8-2 Ma in Central Anatolia. a) when the density difference is decreased to 30 kg m^{-3} the process slows down by ~ 4.5 Myrs and c) when it is increased to 60 kg m^{-3} the removal occurs very rapidly and surface uplift occurs in 3-4 Myrs. Our choice of density difference is also comparable to density difference estimates between the arc root lithosphere and the underlying less dense mantle inferred by Jull and Kelemen [9].



Supplementary Figure 3: Comparison of the geodynamic evolution between dripping lithosphere experiments in which viscosity (μ) of the sub-arc mantle lithosphere (arc root, blue region) is modified a) The viscosity ranges from $\mu = 5.10^{20}$ - 5.10^{22} Pa s for the same strain rate range used in the preferred model (e.g strain rates 10^{-12} to 10^{-17} s^{-1}) b) The preferred experiment (EXP-1) is shown where the viscosity variation ranges between 5×10^{19} - 5×10^{22} Pa s. Note that the increasing viscosity of the arc root delays the dripping process significantly ~ > 10 Myrs, as well the restriction of the amount of proceeding mantle upwelling under the crust.

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