Supplementary file

Numerical modeling

The models are two-dimensional domains with 400 km wide and 100 km deep, representing a trench-perpendicular cross-section of a subduction zone with the trench located to the right of the model. The underplating magma is represented by a 4-8 km thick body located at 100-80 km depth along the bottom of the model. The 8 km-thick magma represents the accumulation of underplating magma due to the subduction. A 10 km thick square domain is assigned at 40 km depth, representing previously intruded magma in the lithospheric mantle. The upper 30 km deep rectangle is continental crust. The polygon located between the underplating magma and crust is mantle lithosphere. A 4 km wide rectangular domain is assigned at the left of the model representing a lithospheric fault.

The equations for heat transport and continuity are solved for plane strain and laminar flow of incompressible fluids using COMSOL Multiphysics, a finite-element software (Chapman, 2021). The resolution is uniform and is physically controlled, but generally represented by a triangular mesh with side lengths of 2-5 km. The top and sides of the model are no-slip boundaries and are fixed, whereas the bottom of the model is a free-slip boundary. Model 2 is assigned a 1e9 Pa boundary force on the right side, representing the compression effect induced by subduction. The sides of the model are thermally insulated and the top and bottom are held at constant temperature of 0°C and 950°C, respectively. The initial temperature of the underplating magma is 1250°C. The models are run using the three-phase flow, phase field interface option, which accounts for the surface tension between immiscible phases, the contact angles with the walls, and the density and viscosity of each fluid. The three phases are continental crust, mantle lithosphere and underplating magma.

The density of the continental crust varies linearly with depth, increasing from 2600 kg/m^3 at the surface to 2900 kg/m^3 at 30 km depth. The dynamic viscosity was calculated using the wet quartz flow law of Hirth et al. (2001). The viscosity was calculated at each time step using the temperatures returned from the model, a quartz material parameter (Aq) of 1.36742x10^{-5} MPa^{-n}/s with a stress exponent (nq) of 4, a quartz activation energy (Q) of 135 kJ/mol, a water fugacity (fH_2O) of 1,000 MPa, and a strain rate of 10^{-15} s^{-1} (Chapman, 2021). The strain rate is based on slab subduction in the numerical modeling studies (Liu and Currie, 2019). The viscosity was updated after each time step based on the temperature. The mantle lithosphere has a constant density of 3400 kg/m3 and a constant dynamic viscosity of 1e21 Pa·s. The molten magma is modeled with a constant density of 2800 kg/m3 and a dynamic viscosity of 1e20 Pa·s. The heat capacity is set to 1000 J/(kg·K), the ratio of specific heat (gamma) is set to 1 and the thermal conductivity is set at 2.5 W/(m·K) in all domains of models (Chapman, 2021).

References

Hirth, G., Teyssier, C., and Dunlap, J.W., 2001, An evaluation of quartzite flow laws based on comparisons between experimentally and naturally deformed rocks: International Journal of Earth Sciences, v. 90, p. 77-87.

Liu, X. and Currie, C.A., 2019, Influence of Upper Plate Structure on Flat-slab Depth: Numerical modeling of subduction dynamics: Journal of Geophysical Research: Solid Earth, v. 124, p. 13150-13167.

Chapman, J.B., 2021, Diapiric relamination of the Orocopia Schist (southwestern U.S.) during low-angle subduction: Geology, v. 49, https://doi.org/10.1130/G48647.1