# 1 Complex phase distribution and seismic velocity structure of the transition zone

Here we give a overview of the model setup.

## 1.1 Model domain

A 2D cylindrical model domain with an opening angle of $90^{\text{deg}}$ is used.

### 1.1.1 Velocity

The set of non dimensional equations that have to be solved (TALA),

$$\nabla \cdot (\rho_r \mathbf{u}) = \mathbf{0} \tag{1}$$

$$-\nabla P + \nabla \cdot \tau = TRa\mathbf{e_z} \tag{2}$$

### 1.1.2 viscosity

for the viscosity we use the relation $\eta(T, z) = \eta_0 e^{(cz-bT)}$ with $b = ln(\delta\eta T), c = ln(\delta\eta P)$

### 1.1.3 boundary conditions

The boundary conditions for the velocity are free slip impermeable for all boundaries.

### 1.1.4 Temperature

The set of non dimensional equations that have to be solved

$$\rho c_p \frac{DT}{Dt} - \alpha\rho u T = \partial_j(k\partial_j T) + \tau_{ij}\partial_j u_i + \rho H \tag{3}$$

with $\alpha\rho u T$ heating due to adiabatic compression, $\tau_{ij}\partial_j u_i$ viscous heating and $\rho H$ radiogenic heating.
The model is heated in the interior with $2 \times 10^{-12} W/kg$ slightly lower than the chondritic value in agreement with the smaller surface/volume ratio of the 2D cylinder.

### 1.1.5 boundary conditions

For the energy equation we prescribe a constant temperature at the bottom and top with a contrast of 3500K the other boundaries prescribe zero heatflux.

## 1.2 Physical properties

The physical properties $\rho$, cp and $\alpha$ appear as coefficients and are included in our model through a general interface based on pressure temperature (P, T ) domain tabulation of the coefficient values in the relevant pressure and temperature range for the Earths mantle.

## 1.3 Lookup table

we need to use a lookup table for the evaluation of these physical properties that depend on pressure and temperature since the number of evaluations of these properties is roughly 200 per element. $N_{eval} = (Nstokes + Nenergy) \times 2 = (Ne \times ng + 3 \times Ne \times 4 \times ng) \times 2 = 26 \times Ne \times ng$ This amounts to $Neval = 5.8 \times 10^6$ table evaluations per integration time step for the finite element mesh size used in our model calculations where Ne = 32000

## 1.4 Initial conditions

Since we have a non nonlinear relation between for instance Temperature and cp we need to apply an iterative procedure to generate the correct initial conditions or temperature and density.
For this purpose we start from a rough estimation of an adiabat truncated by two thermal boundary layers at the top and the bottom of the domain and iterate towards an equilibrium condition.

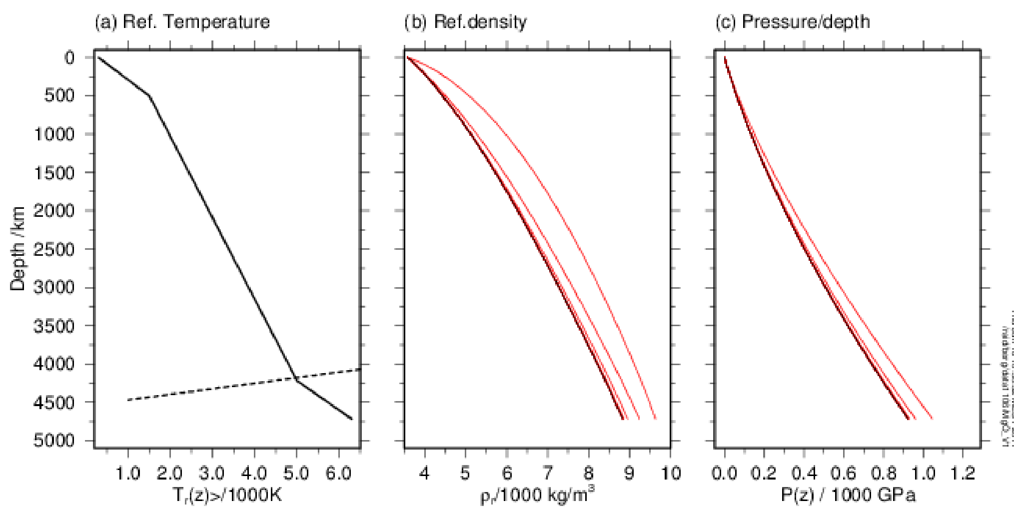


Figure 1: the leftmost frame gives the initial geotherm. The frames on the right give the convergence towards an equilibrium state for density and pressure after several iterations. the black line gives the converged state