A simple view of slab pull

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Compute the velocity of a plate dragged by a vertical slab of length L, thickness d. For simplicity, assume the geometry of the convection cell is a cube. The mantle thickness is H. Consider that the slab has reached 2000km depth such that the mantle flow is global.

- **1-** To compute this, consider the slab as a density anomaly due to temperature. Consider only the weight of the slab as a driving force, neglect the other forces (the velocity will be overestimated a little bit).
  - **1a-** Compute the weight of the slab using a linear approximation of the temperature profile accross the slab.
  - **1b-** Consider a simple form of the Stokes equation where pressure gradients are neglected. The weight that you computed is the source term of stresses. Since we consider the convection cell as a cube, design a very simple distribution of velocities.
  - **1c-** Obtain a strain rate out of it (just one value for the whole convection cell).
  - **1d-** Since the slab has already reached the lower mantle, the lower mantle viscosity is the most relevant one. You now have the weight of the slab (right hand side) and an approximation of the stress divergence (left hand side). Find the velocity of the slab. In fact in this exercise, we use the volume integral of the Stokes equation on the entire convection cell. Since we consider the stresses are homogeneous, the integral is simply the ambiant stress mulitplied by the volume of the convection cell.
  - **1e-** How does your velocity depend on the lithosphere thickness?
- **2-** Add a 6km layer of basaltic material in the slab. Consider that basalt (which will rapidly eclogitize at depth) is 200 kg/m^3 denser than ambiant mantle (a very rough estimate).
  - **2a-** Compute the extra weight in the right hand side of the Stokes equation
  - **2b-** The left hand side is unchanged, which velocity do you obtain?
- **3-** If you are done with question 2, you can try to estimate the impact of phase transitions on the slab pull
  - **3a-** Approximate the temperature anomaly of the slab by a constant. Using the Calpeyron slope, what are the pressure changes of the phase transitions? Clapeyron slope is 1.6 MPa/K for the 410 and -2.5 MPa/K for the 660. If $\Delta T = 650K$, then what is the pressure change?
  - **3b-** Which depth change does this correspond to?
  - **3c-** Compute the extra weight of each phase transition.

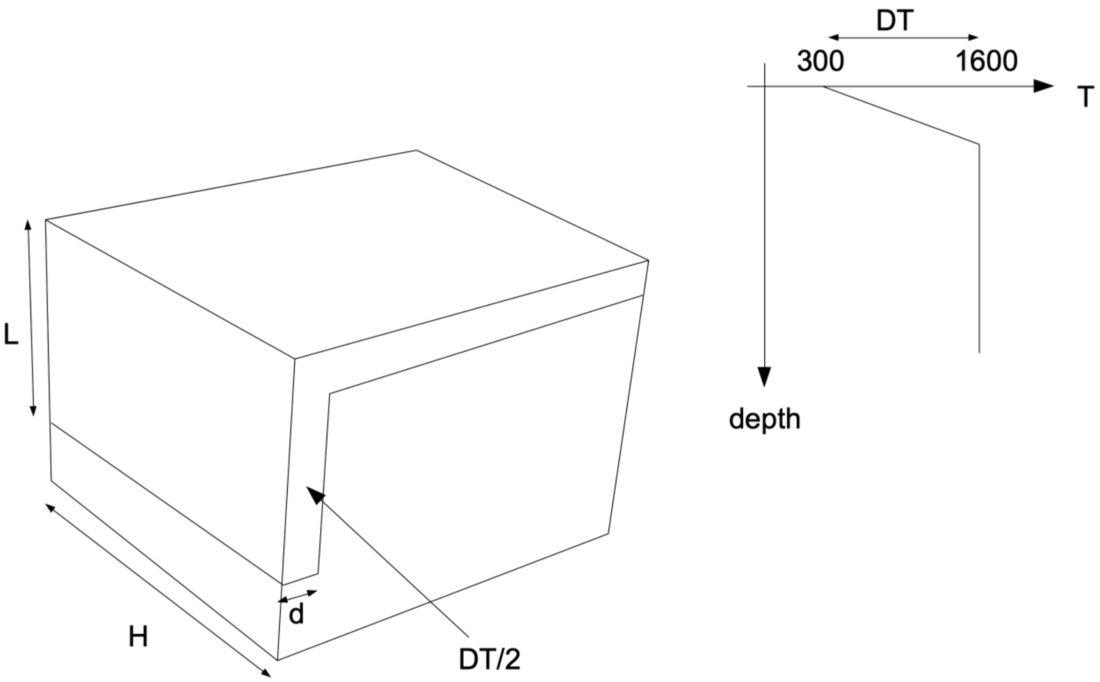

Figure 1: Geometry of the problem