Geodynamics

Plate-driving forces
Lecture 10.5 - Slab pull II

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Goals of this lecture

• Present the part of the slab pull force owing to the olivine to spinel phase transition
Slab (or trench) pull

- **Slab pull** results from the gravitational body force acting on the dense, sinking oceanic lithosphere.

- It can be divided into two components:
  - $F_{b1}$, the force resulting from the slab being colder than the surrounding mantle
  - $F_{b2}$, the force resulting from the elevation of the olivine→spinel phase change

- Mathematically, we can say

$$F_{SP} = F_{b1} + F_{b2}$$
Slab (or trench) pull

- The transition from **olivine to spinel** in the mantle generally occurs at 400-500 km depth, but the transition depends on both pressure and temperature.

- Because the descending slab is relatively cold, the olivine-spinel phase transition occurs at lower pressure (shallower depth).

![Fig. 4.59, Turcotte and Schubert, 2014](http://gji.oxfordjournals.org/content/165/3/S4/fig-f1.large.jpg)
Slab (or trench) pull

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Fig. 4.59, Turcotte and Schubert, 2014

![Diagram of Clapeyron curve and phase transition](http://gji.oxfordjournals.org/)

Fig. 6.43, Turcotte and Schubert, 2014
Slab (or trench) pull

- Thus, the driving force from the phase transition depends on the location of the phase transition isotherm \(T_{os}\) in the sinking slab.

- The driving force from the phase transition is:

\[
F_{b2} = \frac{2(T_c - T_0)\gamma \Delta \rho_{os}}{\rho_0} \left( \frac{\kappa \lambda}{2\pi u_0} \right)^{1/2}
\]

- The olivine-spinel phase transition increases density by \(~270\ \text{kg m}^{-3}\).

\(\gamma\) Slope of Clapeyron curve

\(\Delta \rho_{os}\) Density difference ol \(\rightarrow\) sp

Fig. 6.43, Turcotte and Schubert, 2014
Slab (or trench) pull

- Using typical values for a sinking slab, the gravitational body force due to the olivine-spinel phase transition in the slab $F_{b2}$ is $\sim 1.5 \times 10^{13} \text{ N m}^{-1}$, or about half of that from the difference in temperature alone.

- Going back to our original equation for the slab pull force,

$$F_{SP} = F_{b1} + F_{b2}$$

we find a total slab pull force of

$$F_{SP} = \sim 4.5 \times 10^{13} \text{ N m}^{-1}$$
Let’s see what you’ve learned…

- If you’re watching this lecture in Moodle, you will now be automatically directed to the quiz!

- Reference(s):