Geodynamics

Plate-driving forces
Lecture 10.1 - Essentials of thermal convection

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Goals of this lecture

- Introduce the basic concept of mantle convection and Rayleigh-Taylor instabilities
Mantle convection

- Plate tectonics is ultimately driven by convection in the mantle reflecting heat produced and lost as the Earth cools.

- How convection operates in the mantle is somewhat controversial, but there is clear evidence of fossil plates in the upper and lower mantle.
Layered versus whole-mantle convection

- Layered and whole-mantle convection are end-member models of mantle convection.

- Layered convection is based on the strong seismic discontinuity at 670 km, among other lines of evidence, with the idea that this discontinuity separates upper and lower mantle circulation.
Thermal convection

A fluid heated from beneath will undergo thermal expansion and may become less dense than the cooler overlying fluid.

- This scenario is gravitationally unstable.

- If the denser fluid is able to sink into the less dense fluid, thermal convection will occur.

A Rayleigh-Taylor instability occurs when a denser fluid overlies a less dense fluid, which is gravitationally unstable (the denser fluid wants to sink, and the less dense fluid wants to rise due to its buoyancy).

Fig. 6.21, Turcotte and Schubert, 2014
Thermal convection

- What is going to happen to these two fluids with time?
Thermal convection

Time evolution of a Rayleigh-Taylor instability
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):