Tectonophysics, November 29 2018 13:15-15:15

1. *Switch off your smartphone and put it out of sight*
2. *Head- or earphones are not allowed*
3. *Graphical calculator is allowed*
4. *Answer every question (and just the questions)*
5. *You are allowed to leave the room after one hour after the test has started (late comers will be allowed in during the first hour).*

Assignment 1. Plate model for cooling of oceanic lithosphere

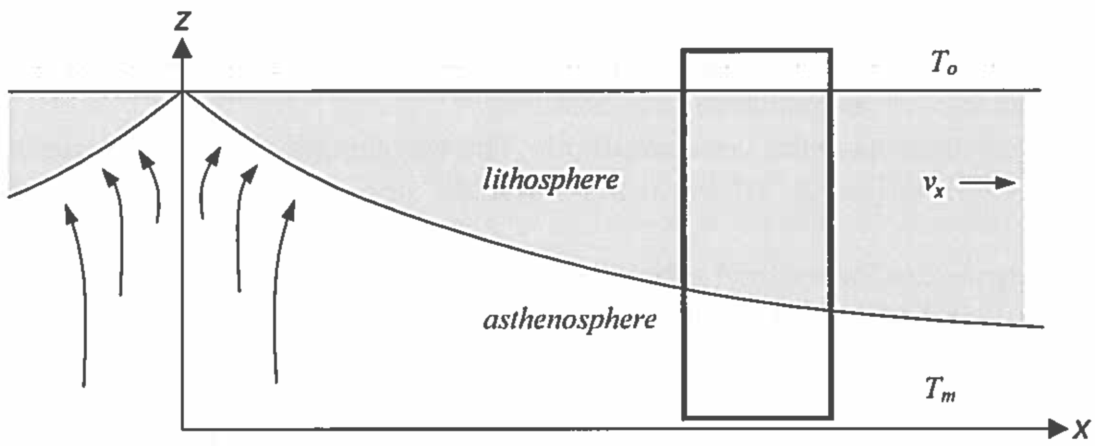

Figure 1. Geometry for derivation of advection-diffusion equation for oceanic lithosphere.

Figure 1 shows a schematic vertical cross section through a cooling oceanic lithosphere. The ridge is located at $x=0$. We consider the plate model with $T(z=0)=T_m$ and $T(z=L)=0$ (i.e., $T_0=0$). The lithosphere moves at with uniform velocity $\vec{v}=(v_x,0,0)$. Derive the non-dimensional version of the 2D advection-diffusion equation for the oceanic lithosphere. Assume that the box stays at a constant distance from the ridge (Eulerian frame). Also derive the non-dimensional boundary conditions and the initial condition. The starting point of your derivation is the diffusion equation

$$\rho C_p \frac{\mathrm{d}T}{\mathrm{d}t} = \nabla \cdot (k \nabla T)$$

where ρ is mass density, C_p is specific heat at constant pressure, T is temperature, t is time, and k is the (scalar) conductivity.

Assignment 2. Flexure of a uniform viscoelastic plate

A uniform viscoelastic plate is subjected to a periodic surface load:

$$q(x) = H\rho_c g \cos kx \tag{2}$$

where H is the height of the load, ρ_c the mass density, and k the wavenumber. The flexural response is given by the following equation:

$$w(x,t)=\frac{\rho_c H\cos kx}{\rho_a}\left[1+(\alpha-1)\exp\left(-\frac{\alpha t}{\tau}\right)\right] \tag{5}$$

where

$$\alpha=\left(\frac{Dk^4}{\rho_a g}+1\right)^{-1} \tag{6}$$

(a) What is the physical meaning of τ? What is its physical unit? Use an example to illustrate your answer (as quantitative as possible).
(b) Two surface loads have the same amplitude. The wavelength of load A is twice as large as the wavelength of load B. Which of the two loads stops subsiding first? Explain your answer.
(c) Find an expression for the final subsidence. Explain as clearly as possible that this is the expected result and derive the result in a different way.

Assignment 3.

(a) What type of observations demonstrate that oceanic lithosphere beneath Hawaii is not (entirely) elastic? Explain your answer.

(b) Which observations in the Pacific ocean show that the lithosphere is not (entirely) viscoelastic? Explain your answer.