Geophysics 150: Home set due Oct. 23, 2002

2. We will make a very simple one-dimensional model of plate tectonics. The mantle conductivity is 3 W m-1 K-1. The volume specific heat of the mantle is 4 MJ m-3 K^{-1}. The surface temperature is for simplicity 0°C. The temperature of the deep interior of the earth is 1300°X. . The rate that new oceanic crust and lithosphere is produced is 3 km^2 yr^{-1}. That is, there is a 3 square km of new oceanic crust produced each year and an equal amount subducted.

a. The globally averaged upward velocity at a depth Z needs to supply a volume of Z times 3 km^2 each year which moves through an imaginary spherical shell depth Z below the surface. Compute this velocity as a function of depth. (1 year is 3.15e7 sec; radius of year is 6371 km. You may ignore the change in radius with depth if you are doing this by hand.)

b. Compute the convective scale length from your velocity as a function of depth Z. At what depth does it equal Z. This is a measure of the lithospheric average thickness.

c. Compute the convective heat flow from upwelling of 1300°C material at that depth with the velocity you obtained. Compute conductive heat flow assuming a rigid lithosphere of that thickness and that basal temperature. FYI: the global heat flow ignoring continents is ~77 mW/m^2.