Ocean 540 (=549b)
Autumn 2002
Problem Set #4

Due Monday, November 4

1. In Problem Set #3 you calculated the heat flux that could be sustained at the upper surface of a 500 m high magma body that is undergoing convection. If that feature is linear along axis and 1 km wide, what is the heat flux per unit length of ridge? How does it compare to that heat flux from a vigorous field like Mike Endeavour Field where the hydrothermal flux is 300 MW/km?

If the magma body were not continually replenished, how long would it take to solidify if 300 MW/km of heat were being removed?

If the hydrothermal system operates at 400 C and the upper surface of the magma body is 1200 C, what would be the thickness of a conductive boundary layer separating the convecting magma and the permeable rock carrying convecting seawater?

(The answers to these questions will seem puzzling. Collectively they define the so-called "Lister Problem": the idea that observed convective heat fluxes are not consistent with long-lived magma bodies. This led Lister to develop his propagating cracking front model for farming heat to sustain hydrothermal convection.)

2. Derive an expression for the onset of Rayleigh Darcy porous convection in oceanic sediment in terms of sedimentation rate and lithospheric age. Estimate the temperature increase across the sediment layer from the conductive plate model. Express the result as a curve drawn through sedimentation rate-lithospheric age space for a sediment permeability of 10^{-16} m^2 . Given typical deep sea sedimentation rates (1-50 m/My) and lithospheric age (< 180 My) where might convection occur?

(It is for this reason that it has been suggested that discharge is primarily associated with permeable faults and outcrops of basaltic basement. However measurements of permeability and lateral pressure gradients do not support such a mechanism. This has recently led Fisher and Becker (Nature 403:71-74 (2000)) to hypothesize that volumetrically rare, very permeable, lateral channels must exist.)