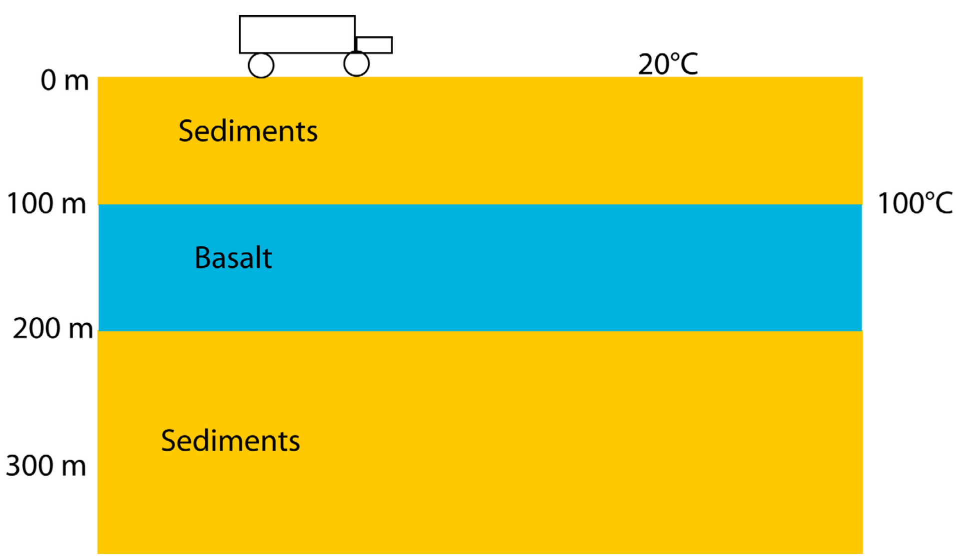
Geophysics 150 Midterm: February 8 2005

1. Simon talked some about the Basin and Range province. You go to a basin where the sediments extend down to considerable depth. You measure that the thermal conductivity of the sediments is 0.8 W m^{-1} K^{-1}, the volume specific heat is 4×10^{6} J m^{-3} K^{-1}, and the density is 2300 kg m^{-3}. The acceleration of gravity is 9.8 m s^{-2}.

   a. You measure the mean annual temperature at the surface to be 20°C. The temperature 100 m down is 30°C. Compute the thermal gradient and the heat flow.

   b. There is a 100-m thick basalt flow with the thermal conductivity of 2 W m^{-1} K^{-1}, starting at 100-m depth. Using that the heat flow is constant with depth compute the thermal gradient in the basalt flow. Sketch geotherm down to 300 m depth.



2. Use material properties from question 1. You are placing a seismic receiver in the sediments. You wish to avoid temperature variations.

   a. How deep to you need to bury it to avoid daily variations in temperature? Use simple formula to get quick estimate. 1 day = ~86400 seconds.

   b. How deep do you need to bury it to avoid annual variation. Give quick estimate. 1 year = 3.15×10^{7} seconds.

   c. Ground water percolates upward in another part of the basin to the surface at 10^{-8} m s^{-1} (30 cm per year). The specific heat of water is 4×10^{6} J m^{-3} K^{-1}. Use simple formula to tell whether you expect the thermal gradient to be constant in a 100-m deep borehole. Sketch the geotherm.

3. Simon talked about the heat generated on a fault during earthquakes. He used the variables density ρ, acceleration of gravity g, coefficient of friction f, (shear) stress on the fault τ, and the rock (lithostatic) pressure on the fault at depth P.

   a. The fault where an earthquake occurs is 4 km down, depth Z. Make simple assumptions to get the shear stress at that depth. Give as equation and show result is dimensionally correct.

   b. The average slip velocity of the fault is V. Get the heat generated on the fault per area per time as a formula. Show that it is dimensionally correct.

   c. Show with dimensions how the answer in part b. is related to the surface heat flow? Sketch would help. How did Simon relate this to the mechanical properties of the San Andreas Fault.

4. I derived the thickness of the oceanic lithosphere, the heat flow, and the topography as a function of age away from the mid-ocean ridge axis. Use simple dimensional formula to show the logic and give dimensional formula for one of the 3 quantities (your choice). Make a sketch of the quantity as a function of age away from the ridge axis.