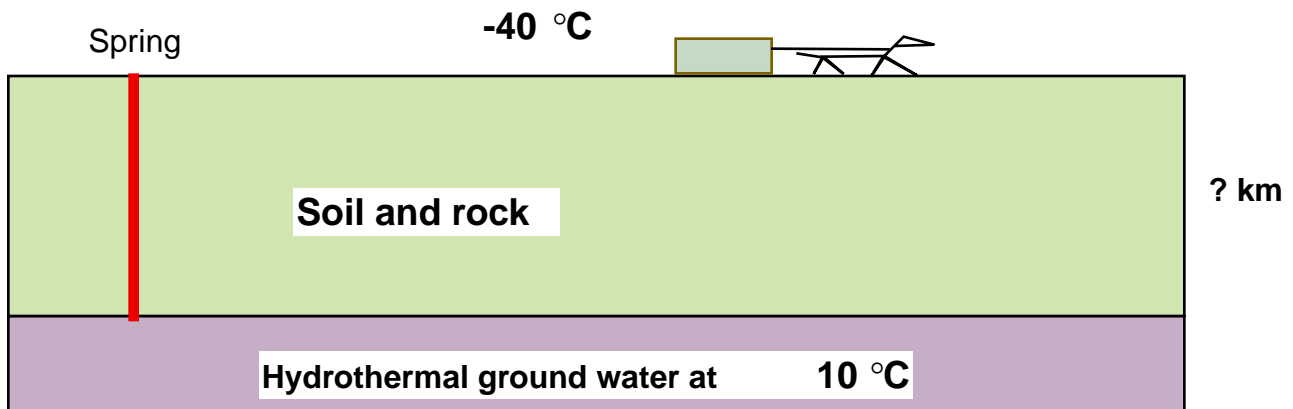


Geophysics 150: Home set due Oct. 18, 2000

1. Hydrothermal springs with temperatures less than $10\text{ }^{\circ}\text{C}$ occur in polar regions and perhaps on Mars. Assume that the soil is frozen and the mean surface mean annual temperature is $-40\text{ }^{\circ}\text{C}$. The thermal conductivity of the soil and underlying rocks is $2\text{ W m}^{-1}\text{ K}^{-1}$. The volume specific heat of the soil and of water is $4\text{ MJ m}^{-3}\text{ K}^{-1}$.



a. The heat flow in the region is known to be 80 mW m^{-2} . Find the depth to the "hydrothermal water."

b. Assume that a thermal gradient to the ambient rock temperature exists at depth around the cylindrical conduit of the spring. The gradient exists over a distance R from the conduit. Find the heat flow per vertical length of conduit using simple approximations. Do you need to know R ?

c. Find the total heat flow over the length of the conduit. About how fast will the water have to flow up the spring so that it does not freeze and clog the conduit.