GEO 390 -- Surficial Geochemistry
Laboratory #7 4/15/08

Stable Isotope Calculations for Surficial Geochemistry

1) Your textbook has a ghastly error in the calculation of the global meteoric water line (GMWL). On page 272 the equation should read:

$$\delta D = 8\delta^{18}O + 10$$

As detailed in this part of the book, the theory of Rayleigh distillation can be used to calculate the stable isotope fractionation during equilibrium processes such as evaporation and condensation. The mathematics are as follows:

$$R = R_o f^{(\alpha - 1)}$$

where R is the isotopic composition of vapor remaining after vapor with initial isotopic composition R_o is condensed, f is fraction of vapor remaining and α is the fractionation factor (which are generally experimentally determined). A fractionation factor greater than unity means that the process will enrich the product in the isotope in the numerator (the heavy isotope of the pair, by convention). Another way of viewing the Rayleigh equation is as follows:

$$\alpha = R_{ppt} / R_{vapor} = (\delta^{18}O_{ppt} + 1000) / (\delta^{18}O_{vapor} + 1000)$$

Which can be rearranged:

$$\delta^{18}O_{ppt} = \alpha(\delta^{18}O_{vapor} + 1000) - 1000$$

Finally, temperature has been calibrated for meteoric precipitation waters as follows:

$$\delta^{18}O_{ppt} = 0.521t - 14.96$$

Where *t* = temperature in degrees C. Note that this simplified expression carries both large errors and significant (undiscussed) assumptions.

The oxygen isotope data gathered at the University of Rochester SIREAL were as follows:

	$\delta^{18}O$
Carthage #11 [groundwater]	-6.4
Vanda, 10m [lake water]	-31.1
Oswego 0308 [snow]	-15.0

a. Use the D-O isotopic relationship for global meteoric water to calculate the values of δD that would be in equilibrium with these data.
b. Make a plot of the GMWL and our data, using your calculated δD.
c. Using the temperature relationship, compare the estimates of temperature from the Oswego snow sample and the Lake Vanda sample, based on their oxygen isotopes.
d. Using the oxygen isotopic compositions of the snow and Lake Vanda waters, and assuming these are meteoric waters derived directly from precipitation with α = 1.0092 and no other changes, calculate the $\delta^{18}O$ of the cloud water vapor from which these two formed.
e. What does the calculation in (d) fail to take into account that is likely affect the validity of the result?

Solutions are due next lab period (4/22/08).