**GEO 390 -- Surficial Geochemistry**
**Laboratory #6 4/8/08**

## Elemental and (Radiogenic) Isotope Mixtures in Surficial Geochemistry

For binary (two-component) mixtures, we use the following mathematics to determine the concentration of element X in a mixture:

$$X_m = X_A f_A + X_B(1 - f_A)$$

where: $f_A = W_A / (W_A + W_B)$

Similarly, concentration of element Y is then:

$$Y_m = Y_A f_A + Y_B(1 - f_A)$$

Note: this applies principally to elements that behave conservatively under the given conditions.
If we consider mixtures of both elements X and Y, then it can be show that a linear relation develops:

$$m = \frac{Y_A - Y_B}{X_A - X_B} \quad \text{and} \quad b = \frac{X_A Y_B - X_B Y_A}{X_A - X_B}$$

| | Ca (ppm) | Sr (ppb) | % Huron |
|---|---|---|---|
| **1** | 18.0 | 43 | |
| **2** | 18.1 | 49 | |
| **3** | 21.0 | 61 | |
| **4** | 21.5 | 69 | |
| **5** | 22.0 | 73 | |
| **6** | 22.2 | 68 | |
| **7** | 24.2 | 85 | |
| **8** | 25.1 | 78 | |

1) The data in the table above are for Lake Huron waters, where they mix with Lake Superior.
a. Plot the data on an x-y plot (x = Sr) and determine the best-fit line through the data.
b. Assuming Ca in Lake Huron water is 26.9±0.3 ppm and in Lake Superior it is 14.4±0.2 ppm, calculate the Sr concentrations of the end member Sr concentrations.
c. Plot the end member concentrations and determine the proportion of Lake Huron water in each mixed sample.

The same kind of mixing can be assessed for mixtures of elements and radiogenic isotopes, for example Sr and $^{87}Sr/^{86}Sr$.

$$\left(\frac{^{87}Sr}{^{86}Sr}\right)_m = \frac{a}{Sr_m} + b$$

where

$$a = \frac{Sr_A Sr_B\left[\left(\frac{^{87}Sr}{^{86}Sr}\right)_B - \left(\frac{^{87}Sr}{^{86}Sr}\right)_A\right]}{Sr_A - Sr_B}$$

and

$$b = \frac{Sr_A\left(\frac{^{87}Sr}{^{86}Sr}\right)_A - Sr_B\left(\frac{^{87}Sr}{^{86}Sr}\right)_B}{Sr_A - Sr_B}$$

This gives a hyperbola if Sr concentration is used, and a straight line if the same data are plotted as $^{87}Sr/^{86}Sr$ versus 1/Sr.

2)

| | Sr (ppm) | $^{87}Sr/^{86}Sr$ | | Sr (ppm) | $^{87}Sr/^{86}Sr$ |
|---|---|---|---|---|---|
| 1 | 799 | 0.71050 | 4 | 992 | 0.71082 |
| 2 | 801 | 0.71091 | 5 | 1140 | 0.70911 |
| 3 | 920 | 0.71056 | 6 | 1390 | 0.70895 |

a. Plot the mixing line or hyperbola for mixtures of saline groundwater with 750 ppm Sr and $^{87}Sr/^{86}Sr$ = 0.71310 and brine with 1400 ppm Sr and $^{87}Sr/^{86}Sr$ = 0.70837.

b. Plot the data from the above table and compare to the binary mixing line. How well does binary mixing explain these waters?

3) The calculation of the normalize Nd isotopic composition of a sample is:

$$\varepsilon_{Nd} = \left( \frac{\left(\frac{^{143}Nd}{^{144}Nd}\right)_{sample}}{\left(\frac{^{143}Nd}{^{144}Nd}\right)_{CHUR}} - 1 \right) x10{,}000$$

Note: CHUR (present-day): $^{143}Nd/^{144}Nd$ = 0.512636

a. Calculate the present-day $\varepsilon_{Nd}$ for a sample with $^{143}Nd/^{144}Nd$ = 0.512479±0.02%.

b. What is the error (absolute, not percent) on this datum, given the uncertainty on the measured isotope ratio?

**Solutions are due next lab period (4/12/08).**