**GEOL 135 Lab – REE partitioning in melts and granite weathering**

**The Rare Earth Elements (REE)**

The lanthanide series is formed by filling of 4f orbitals, and its constituents are commonly termed the rare earth elements (REE). The common valence state is +3 for all REE over a wide range of oxygen fugacity; Ce4+ can occur in highly oxidized environments at the earth's surface, and Eu2+ in reducing environments in the crust and mantle. The rare earth elements are lithophile elements (low electronegativities lead to the formation of highly ionic bonds), which substitute into many silicates and phosphates. Ionic radii of the lanthanides decreases with increasing atomic number from La to Lu, called the ***lanthanide contraction…***

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Because of their high charge and large radii, the rare earth elements are usually

relatively **incompatible** in silicate minerals. However, due to the lanthanide contraction,

the heavier rare earths are smaller and thus can "fit" within some lattice sites (although

there must be charge compensation for the 3+ valence), so incompatibility decreases

with increasing Z.

**1. Producing REE diagrams**

REE diagrams are plotted as concentration on the y-axis and each REE represented on the x-axis. Using the chondrite REE data (in ppm by weight), plot the diagram for REE (La though Lu) corresponding to the chondrite composition on Table 1 using excel (try making a LINE plot).

Why does the element concentration vary significantly in this fashion?

Since the effect plotted for chondrite REE affects all rocks, we typically normalize all REE analyses based on the chondrite values so we can see effects associated with other phenomena. Plot the N- and E-type MORBs (N-MORB is a ‘normal mid-ocean ridge basalt, E-Morb is an ‘enriched’ MORB), OIB (Ocean Island Basalt, a mantle plume material), and a granite as CHONDRITE-NORMALIZED compositions on an REE plot, discuss the major differences.

Table 1 – selected REE data for selected rocks to use in these exercises

**2. Rayleigh Fractionation of elements as melts crystallize**

As melts crystallize, elements enter certain minerals according to a partitioning coefficient, KD (for a comprehensive list of KD values, see: <http://earthref.org/cgi-bin/er.cgi?s=kdd-s0-main.cgi>). Using the chondrite-normalized data above as a starting point and the KD data in Table 2, plot how Sm, Nd, Eu, and Yb would change as a function of melt crystallization as Plagioclase and Clinopyroxene crystallize, and then discuss how an OIB mantle material could be produced…

Use the Rayleigh Fractionation equation for this:

Cimelt = Ci0rockF(KD-1)

Where the initial melt concentration for any element is Cimelt ,the concentration of any element in the rock or mineral under consideration is Ci0rock. , KD is the partition coefficient, andF is the fraction of melt remaining. Here the REE concentrations for the chondrite is the initial

Table 2 – selected KD values for Plagioclase and Clinopyroxenes

**3. REE changes as granite weathers**

REE are often conservative, in other words REE distributions of minerals forming sediments are representative of the parent rocks they come from, with some caveats. We will investigate how REE changes as a function of granite weathering and the minerals REEs are coming from as granite dissolves. Table 3 lists REE for Granite and the major minerals in granite (Data from Aubert et al., 2001 GCA) in addition to soil, river sediment, soil porewater, and river water analyses.

Plot the REE patterns of each sample and calculate apparent KD for each mineral.

Investigate this dataset and address the following:

If river sediment is deposited and eventually forms a fluvial sedimentary rock, how well is the REE preserved, and what elements see the most difference. Address why these specific REE distributions may be different. Discuss this with supporting graphs and calculations.

