Geochemistry --- Thursday, 30 May 2019

Sm-Nd isotopes *(due Wednesday 5 June 5 PM)*

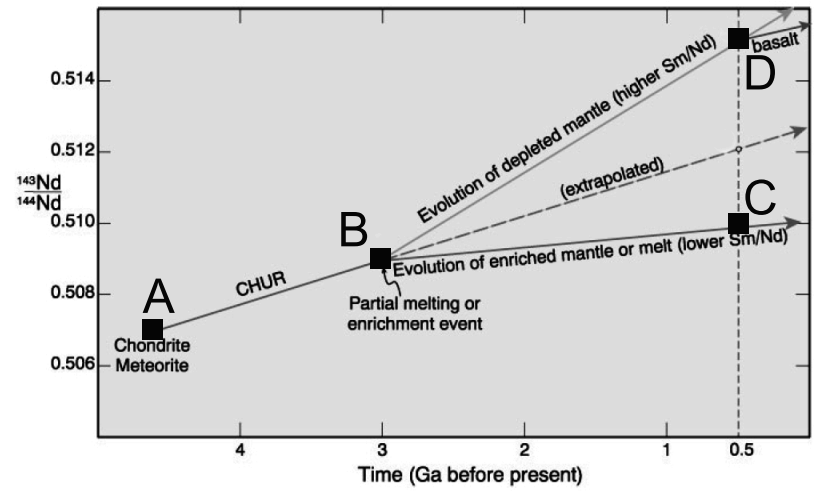
Objective

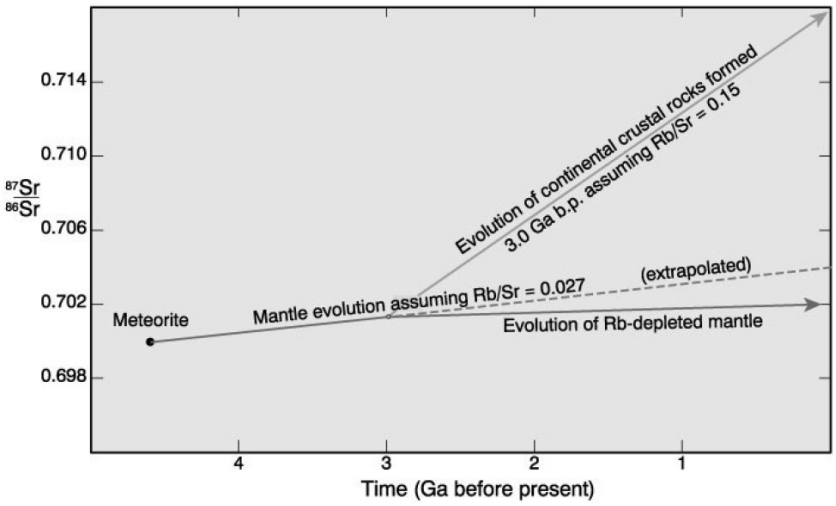
Exploring Sm-Nd isotopes in dating and tracing Earth differentiation.

Background

During partial melting of Earth's mantle causes Sm fractionates from Nd; crustal differentiation (e.g., partial melting and/or crystal fractionation) has a minimal effect on Sm/Nd. Thus, the measured Sm/Nd and the Nd isotopic composition of a sample can be used to calculate a "model age" (mantle extraction age) of when the precursor of the rock differentiated from the Earth's mantle. These model ages are generally calculated relative to a chondritic (T_{CHUR}) or depleted mantle (T_{DM}) evolutionary model.

1. a) Given the Nd isotope evolution diagram, what do points A, B, C, and D on the figure represent?
   b) Given the following two isotope evolution diagrams, explain the differences in the two isotope systems? How might these systems differ if one used the evolution of the Depleted Mantle as the reference frame (instead of the CHUR reference frame)?





c) Sketch a likely chondrite-normalized REE pattern for the residual mantle, the igneous rock and CHUR in part a.

2. Calculate the $^{143}Nd/^{144}Nd$ ratio of CHUR (chondritic uniform reservoir) at 2.5 Ga given that the present $^{143}Nd/^{144}Nd$ for CHUR=0.512638 and that $^{147}Sm/^{144}Nd$=0.1967. The ^{147}Sm half-life is 106 Ga.

3. Given a sample with an initial $^{143}Nd/^{144}Nd$ = 0.51100 at 1.8 Ga, what is it's ε_{Nd} relative to CHUR at that time? First you will need to calculate the $^{143}Nd/^{144}Nd$ of CHUR at 1.8 Ga using the isochron equation and the information provided in question 2 (see lecture notes), then calculate ε_{Nd} at 1.8 Ga.

4. a) Calculate a model age relative to CHUR for a rock given the following data: Sm = 0.580 ppm, Nd = 1.539 ppm, $^{143}Nd/^{144}Nd$ = 0.513101. The isotopic abundances for ^{147}Sm and ^{144}Nd are 15% and 23.9%, respectively. (hint: you are looking for a intersection of two lines such as the one in Problem 1).

b) Plot the evolution lines for CHUR and the rock in part (a) in epsilon vs. age (time) space.