GEOL 5690 Homework 1 2024
Due 2 February 2024

How precisely do we have to measure things in order to get a precise U-Pb date? A few pieces of information might be of help. Modern day $^{238}U/^{235}U$ ratios are generally considered to be 137.88. Zircon has a density of 4650 kg/m$^3$. Ideally, zircon has no lead when it first forms, so all the lead in zircon should be considered radiogenic for this exercise [in reality, there can be contamination, which complicates things].

1. Consider the equations for $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ age dates in the handout. For a sample 20 million years old, how precisely must we know the $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ratios to have an uncertainty of 0.5 million years? How about a sample 2.0 billion years old? Which sample requires greater absolute precision? Which requires greater relative precision (i.e., error as a percentage of the measurement)?

2. The concentration of uranium in zircon varies considerably. If it is 90 ppm by weight, how much zircon do you need in order to get 5 ng of uranium (an amount you might want for a "traditional" TIMS [thermal ionization mass spectrometer] measurement)?

3. Another method, laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) ablates spots as small as about 12 microns in diameter and perhaps 10 microns deep. How would this sample size compare with the one calculated for a TIMS measurement?

4. LA-ICP-MS ages for zircons younger than about 1.2 Ga are generally determined from $^{206}Pb/^{238}U$ ratio ages. Assuming that the limiting factor is the amount of lead of the proper isotope present in the sample, for a sample of age 200 Ma of dimensions as stated in question 3, what size sample would be required to get the same precision for a $^{207}Pb/^{235}U$ age? Assume the same 90 ppm of U in the sample as above.