EarthScope Student Geochronology Research and Training Program Laboratory Overview
Princeton University U-Pb ID-TIMS geochronology facility
7/29/13

Lab Description

The Princeton University isotope geochemistry laboratory is fully equipped to carry a sample from rock to high-precision U-Pb geochronology data. Equipment includes standard rock crushing machines and setups for density and magmatic separation of minerals. Mineral separates are commonly (e.g. in the case of zircon) mounted in epoxy, polished, and imaged by backscatter and/or cathodoluminescence to reveal internal zonation prior to selection for geochronology. Single grains or grain fragments are selected and removed from grain mount under binocular scopes and transferred to teflon microcapsules in batches of 18. In the clean lab facilities, grains are leached, spiked with the EARTHTIME mixed U-Pb tracer solutions, dissolved, and put through anion exchange columns. Isotope ratios are measured by an IsotopX PhoeniX thermal ionization mass spectrometer. Optional capabilities include measuring trace element concentrations of the same minerals dated (so called U-Pb TIMS-TEA) on an Thermo Element2 single collector SF-ICPMS, also housed in the department. Minerals commonly analyzed include zircon, apatite, titanite, monazite, allanite, and rutile (inquire if other minerals are of interest).

Expected Time Frame

A minimum of 1.5 weeks is required to carry out the steps listed above, excluding rock crushing and mineral separation, grain annealing (required for zircon), and mass spectrometry. To run some of the samples on the mass spectrometer, allocate an additional few days, or two weeks total. This will result in a maximum of 36 single minerals put through the anion exchange chemistry step. Running these on the mass spec, will take ~180 hours of mass spec time, which is included in the per sample fee and will be done mostly after the student leaves Princeton.

The following is a list of the steps followed and the time required for each step, on a per sample basis. Times can be reduced slightly if carried out on multiple samples at a time.

<u>Mineral separation (~1 day per sample):</u>

- Coarse sledging of rock, 1st stage crushing, 2nd stage grinding (3 hours)
- 1st stage water-based density separation, 2nd stage heavy-liquid separation, magnetic separation (5.5 hours).

<u>Grain mounting/imaging (2 days per sample, excluding annealing):</u>

- Anneal grains (zircon only) (48-60 hours)
- Pick grains and make epoxy mount (4 hours, epoxy sets over night)
- Image grains on SEM (2 hours)
- Interpret images, select grains for geochronology (2 hours)

<u>Clean lab (6 days):</u>

- Remove chosen grains from epoxy (18 grains, 3 hours total)
- Transfer grains to teflon microcapsules (3 hours)
- For zircon: leach in HF overnight for 12 hours
- 1st stage rinse (30 mins), flux on hotplate (6 hours), 2nd stage rinse (3 hours), spike (30 mins)
- Dissolve grains in oven in HF for silicates, HCl for phosphates (48 hours)
- Dry down dissolved grains and put back in oven overnight in HCl (4 hours dry, overnight)
- Prepare for column chemistry – includes beaker cleaning, column steup/cleaning (4 hours)

Mass spectrometry (5 hours/grain)

- Load U and Pb separates onto single filaments (10 mins/grain)
- Analyze U and Pb isotopes (5 hours/grain)

Analytical Costs

Students should envision analyzing a minimum of ~9 grains/sample and thus a maximum of 4 samples at a cost of $1500/sample (costs here based on 15 grains/sample, not including rock crushing/mineral separation). A training fee of $500 should also be budgeted, which includes the ~50 hours of hands-on training the student will receive (very few of the steps listed above can be carried out unassisted). The rocks can be crushed and minerals separated prior to the student's arrival, at a cost of $200/sample. If student wishes to arrive early and process samples him/herself, a rate of $75/sample in consumables should be budgeted. An additional $200/sample is charged for trace element analyses of minerals dated, which will likely be carried out after the students departure.

Preparation for Visit

We recommend that students arrive at Princeton with minerals already separated and (in the case of zircon) annealed. As noted above, this can be done at Princeton prior to their arrival for a fee (annealing can be done free of cost prior to arrival if minerals are shipped head of time). Many universities, colleges and institutions have at least some of the equipment need for rock processing available, so the student should look into that before submitting the proposal. Commercial mineral separation facilities exist as well, and we can supply names of these if needed, and the student can check into their rates.

Relevant Laboratory Staff

The Princeton University geochronology lab is run by Prof. Blair Schoene. Its upkeep is carried out by Schoene, his PhD students, and post-docs. One of these people will assist visiting students and train them through in step of the procedure. Continued mass spectrometry will be carried out primarily after the student's departure by one or more of these people as well.

Data Processing and Interpretation

Ideally, there will be time allocated by the student to spend a couple days running samples on the mass spectrometer before they leave. The student will then have seen and participated in the entire procedure of ID-TIMS U-Pb geochronology from start to finish. During mass spectrometry, the student will get to use mass spec software and also data interpretation and reduction software required to calculate dates and make concordia diagrams. This software is designed to educate novice users and build an understanding of sources of uncertainty and their propagation to final age. Lab staff will help the student understand this procedure as well as interpret the dates in terms of the geology of their specific project. This interpretation will continue after the student's departure, with continued assistance from various members of the lab staff and Schoene.

Expected Lab Availability

In most situations, students may schedule time in the Princeton lab with 2-3 months advanced notice.