Yiming Zhang - Project Profile

2023 AGeS-Grad awardee
Project Title: Dating the Grenville Loop using U-Pb apatite thermochronology
Lab: Boise State isotope Geology Lab
Lab Mentors: Mark Schmitz

What scientific question(s) does your research address and what motivates this work?
This project focuses on reconstructing late Proterozoic global geography by developing U-Pb apatite thermochronology data that are paired with paleomagnetic data. The project is motivated by there being a lack of well-dated paleomagnetic poles that constrain the paleogeography of ancient North America ca. 1075-775 Ma — a critical interval when North America was at the center of the supercontinent Rodinia. Previously, paleomagnetic poles developed from metamorphic rocks of the Grenville orogen had been interpreted to fill this gap leading to a pole path known as the Grenville Loop. However, the ages of these poles are associated with the timing of exhumation of the orogen. With this project, I aim to develop new constraints on the history of exhumation of the Grenville orogen and the age of the Grenville paleomagnetic poles using apatite U-Pb ID-TIMS data and LA-ICP-MS data.

What chronometric tool did you employ and why?
I used the U-Pb apatite thermochronometer for this project. Magnetic minerals in the metamorphic rocks of the Grenville orogen acquired magnetic remanence through a thermally activated process as they cooled through a critical temperature range. This process is analogous to thermochronometers recording timing of geologic events by (partially) retaining radioisotopes when cooling through their closure temperatures. Previous paleomagnetic and rock magnetic data developed from rocks of the Grenville orogen indicate they acquired magnetic remanence at temperatures ranging from 580ºC to 500ºC. The nominal closure temperature range of apatite U-Pb system is typically 370ºC to 570ºC. This makes apatite U-Pb thermochronometry a great match for dating the paleomagnetic records in the Grenville orogen. With the modern high-precision ID-TIMS technique and high-spatial resolution LA-ICP-MS technique, we can exploit bulk apatite grain size-age correlations and depth profiles to infer for the post-peak metamorphism cooling history of the Grenville orogen in a quantitative framework.

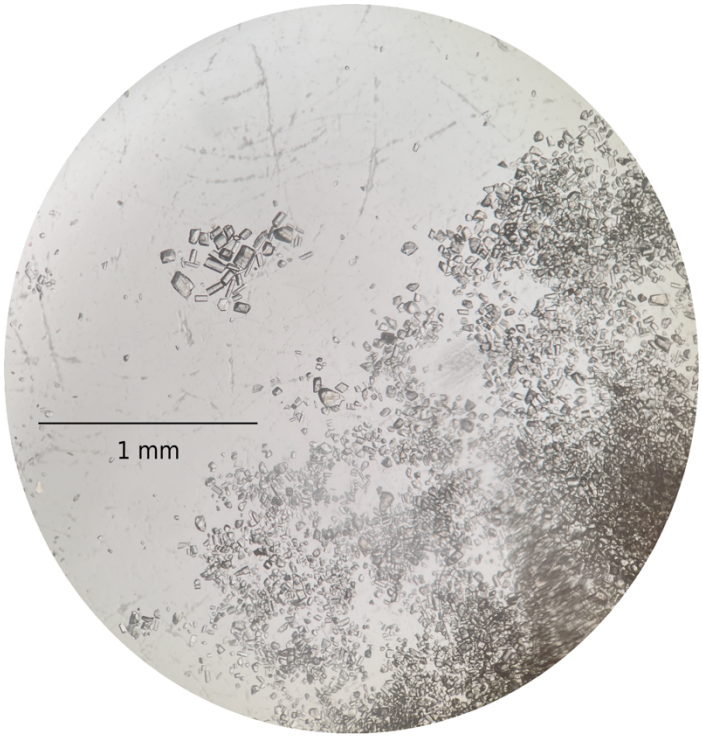

Figure 1. Hand-picked apatite grains from a Grenville orogen rock sample's heavy mineral separates.

What were some of the key takeaways of your research?

1. There are abundant U-rich apatite grains in exhumed Grenville plutonic rocks from which paleomagnetic records can be measured
2. In situ LA-ICP-MS analysis is crucial for screening for grains with high U concentration and to constrain common Pb ratios in samples
3. U-Pb ID-TIMS dates provide the tightest constraints on cooling and exhumation for subsequent thermal history modeling in this age range

What new experiences, opportunities, and collaborations did you gain as an AGeS-Grad awardee?

During the lab visit I gained a whole new set of geochronology laboratory and data analyses tools. I also attended the geochronology lab PI's lectures and learned new isotope geochemistry knowledge. I am planning on continuing collaborating with the Boise State Isotope Geology Lab as a postdoctoral associated at my new institution. I look forward to continuing learning and doing geochronology in my future career.

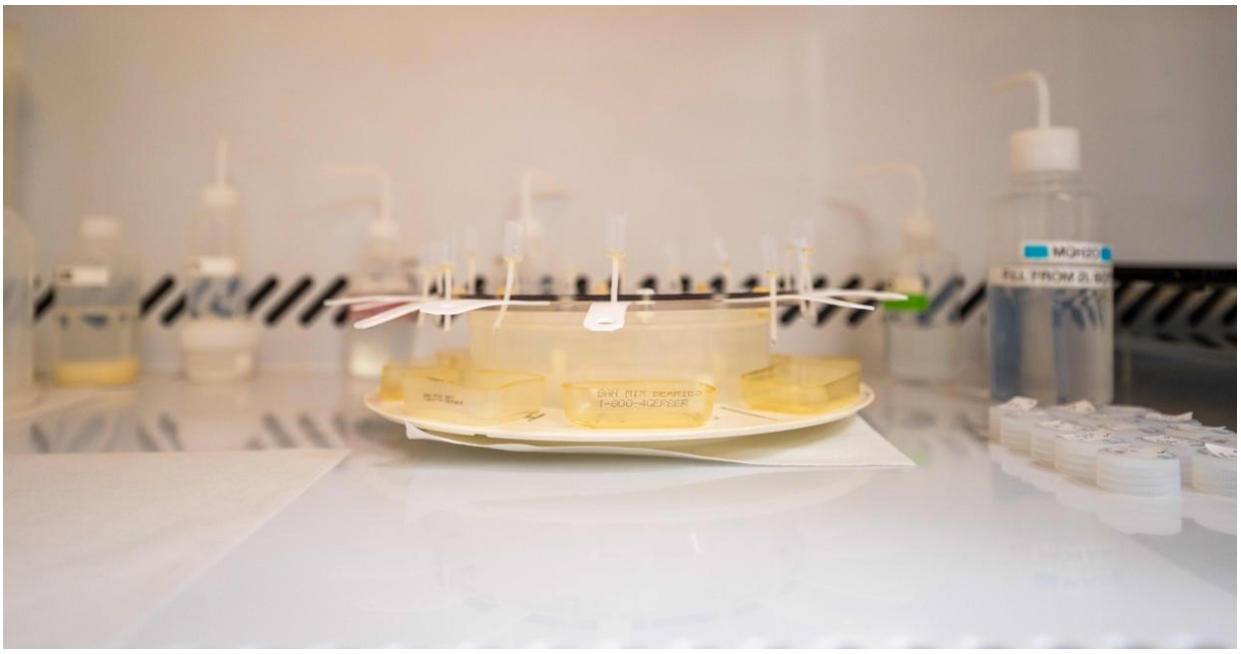

Figure 2. U-Pb ion exchange column chemistry experiment during my lab visit.

What is one piece of advice you have for future AGeS-Grad award applicants or awardees?

I recommend that students schedule pre-visit meetings with the advisors and plan the research early.

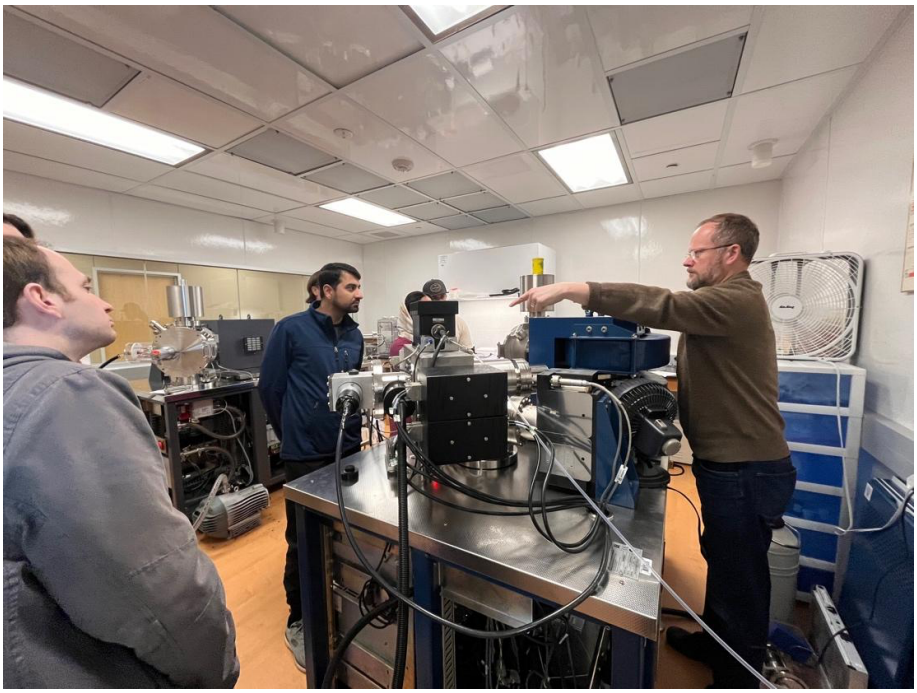

Figure 3. Host lab PI, Prof. Mark Schmitz, giving a lecture on thermal ionization mass spectrometry and showing the thermal ionization mass spectrometers in the Boise State Isotope Geology Lab.