Basin Analysis and Helium Thermochronology Laboratory

An NSF supported facility at the University of Connecticut

Laboratory Overview

Welcome to our lab and thank you for working with the Basin Analysis and Helium Thermochronology Laboratory at UConn! BAHTL houses analytical instrumentation and sample preparation facilities to support research in low-temperature (U-Th-Sm)/He thermochronology. Our lab includes sample preparation facilities and an integrated gas extraction and measurement line.

Personnel

Lab maintenance, sample preparation, and visitor training duties are shared by Prof. Julie Fosdick and laboratory technician Dr. Adam Goldsmith. Our goal is to work with you to generate high-quality thermochronology data. We encourage you to contact us with questions about project design, methods, and data analysis.

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More information can be found at: https://thermochron.uconn.edu/lab/

Sample preparation and microscopy

Our sample preparation facilities for (U-Th-Sm)/He analysis include a Leica 165C high resolution stereomicroscope with a 360° rotating polarized stage, polarized analyzer, transmitted and reflected light sources, bright- and dark-field capabilities, and an ergonomic trinocular tube. Crystal morphometrics of selected samples are collected using a Leica MC170 HD Camera and LAS Interactive Measurement software. The lab provides sample preparation supplies including glass petri dishes, slides, tweezers, and Nb foil tubes. We currently analyze single-crystal aliquots of apatite and zircon samples, but procedures can be modified based on project scope.

Apatite and zircon crystals from samples are hand-picked, screened, and photographed under 120x magnification and cross-polarized light for quality, crystal size, shape, and the absence of inclusions. Crystal size measurements of selected grains are collected from these high-resolution images to calculate crystal mass and alpha-ejection correction factors used in the (U-Th-Sm)/He age analysis. Individual crystals are then loaded into 1 mm diameter Nb foil packets for stable heating during gas extraction.

He gas extraction and analysis

Nb packets containing the mineral aliquots are loaded into the He gas extraction line and pumped down to high vacuum (<10^{-8} torr). Packets are then heated with a diode laser at 1000-1250°C for 3 to 15 minutes (depending on mineral type) to extract radiogenic ^{4}He. Sample gas is spiked with ~7 ncc of pure ^{3}He, cleaned using getters and cryogenic purification, and analyzed on a quadrupole mass spectrometer. Aliquot ^{4}He gas concentrations are calculated from these data.

BAHTL houses a Santa Cruz Laser Microfurnace helium gas extraction line equipped with a Pfeiffer PrismaPlus quadrupole mass spectrometer, Jenoptik laser diode system, Advanced Research Systems cryogenic trap, and sample cells for both standard gas extraction and step-heated diffusion experiments. High vacuum within the stainless-steel extraction line and mass spectrometer is maintained by a Gamma vacuum ion pump, a Pfeiffer turbo pump, a Pfeiffer HiCube 80 Eco pumping station, and a series of valves and gauges.

Mineral dissolution and U-Th-Sm analysis

Following He isotope measurement, degassed aliquots are sent to the Thermochronology Research and Instrumentation Laboratory (TRaIL) at the University of Colorado to complete mineral dissolution and measurement of parent U-Th-Sm isotopes via ICP-MS analysis. U, Th, and Sm measurements from TRaIL are combined with blank-corrected He concentrations associated grain morphometric data to calculate (U-Th-Sm)/He dates. For instrument calibration and data quality-control, we routinely analyze procedural blanks and mineral standards (Durango Apatite and Fish Canyon Tuff Zircon) at no additional cost to the visitor.

Overview of lab procedures for visiting students and researchers

Diversity, Equity, and Inclusion in the BAHTL

We work to make our laboratory environment an inclusive and supportive space for all visitors and lab members. In the BAHTL, we believe that science is strongest with the inclusion and diversity of ideas, experiences, and perspectives in all forms. We support students, visitors, and staff from underrepresented and minoritized backgrounds and strive to create a safe working environment free from discrimination and harassment based on race, sex, sexual orientation, gender expression, physical ability, body size, religion, age, or ethnicity. Hostile behavior, discrimination, and bullying will not be tolerated. We promote ongoing discussions, active engagement, and continual learning on topics related to diversity, equity, and inclusion. We have numerous university resources from the Office of Institutional Equity that outline our policies on discrimination in the workplace. Lab personal and visitors with concerns or questions on these issues are encouraged to speak with Dr. Fosdick.

Procedures and workflow

During a typical visit, student visitors will select and prepare sample aliquots using our microscope and imaging facilities. With additional training, students may also load samples into the He line and carry out the laser heating gas extractions. BAHTL personnel provide training to visiting researchers on laboratory safety, sample preparation procedures, and He gas extraction and measurement. National Science Foundation Award #1735492 supports full-time appointment of a laboratory technician whom provides visiting researchers with

training and supervision. Currently, student training and supervision are carried out by Prof. Julie Fosdick and laboratory technician Dr. Adam Goldsmith at no cost to the researchers. When sample degassing has been completed (including standards), BAHTL personnel will prepare samples for shipment to CU TRaIL for mineral dissolution and U-Th-Sm analysis. Students will learn how to use their data to calculate He gas and parent U-Th-Sm concentrations, alpha-ejection correction factors, and (U-Th-Sm)/He dates. BAHTL personnel will also provide guidance to students for making preliminary data interpretation and modeling strategies.

Analytical costs and scheduling

We generally analyze single-crystal aliquots and recommend ~4-5 crystals per crystalline sample (for samples with predicted monotonic cooling histories). Samples for which anticipated thermal histories are more complex, and/or detrital samples require customized procedures and/or a larger number of single-crystals per sample. For scheduling, we recommend budgeting one week to complete training, sample preparation, and He gas analysis for five samples within the sampling guidelines listed above. In general, students should be able to schedule lab time with 3-5 months lead time.

Students who plan to prepare and degas their own samples should budget $112 for each zircon aliquot ($336/sample, for n = 3 zircon crystals), and $37 for each apatite aliquot ($185/sample, for n = 5 apatite crystals).

Assisted facility and equipment operation

Upon request, BAHTL staff will prepare samples and operate the equipment on behalf of the researcher. This work may include preparing the material sample, setting up the equipment to analyze the sample, monitoring the sample run, and ultimately providing the resulting data for the researcher for their specific use. This operation may be performed by a specifically trained and authorized undergraduate student or other research staff, supervised by the lab technician. Students who plan to ship us their samples for preparation, He analysis, and U-Th-Sm analysis should budget $142 for each zircon aliquot ($426/sample for n = 3 zircon crystals), and $73 for each apatite aliquot ($365/sample for n = 5 apatite crystals). Depending on the nature and scope of the analytical work (client visit versus full-service), data are typically available within 4-6 months of sample preparation. (**covid-19 update: please be aware that our lab is operating at a reduced pace due to health and safety restrictions during the pandemic. A more realistic estimate from samples-to-data is ~5-7 months, pending additional closures. We will do everything in our capacity to ensure you receive data as soon as possible). We will provide students with sample images and a data table with sufficient information for publication as well as a basic description of methods used for sample preparation and data reduction. All publications that include (U-Th-Sm)/He thermochronology data from the BAHTL should include information on general analytical methods as provided by BAHTL.

Other Laboratory Policies and Considerations

Sample quality: Sample (U-Th-Sm)/He methods are reliant upon the presence of acceptable mineral specimens. If the mineral separates do not contain sufficiently high-quality crystals (e.g., inclusion-free apatite), they will yield no usable data. We encourage visitors who wish to prepare their crystals on site to send their mineral separates in advance so that we may screen them for quality.

Scheduling: BAHTL maintains an ultra-high vacuum line with many operating parts and supporting infrastructure, including a Class 4 laser system, cryogenic cooler, and quadrupole mass spectrometer. BAHTL staff maintains these systems for visitors and internal use. However, in rare cases, vacuum leaks, equipment failure, or building facilities disruptions may require deviation from the planned schedule. BAHTL personnel will work with visitors to make the most reasonable alternative arrangements (**covid-19 update: please be aware that our lab is operating with some restrictions due to health and safety concerns during the pandemic. At this time, we are not scheduling external lab visitors without UConn Provost approval).

Collaboration: BAHTL is a facility that is focused on hosting visitors for on-site sample preparation and analysis, collaborative projects, and fee-for-service (U-Th)/He thermochronology. We do not expect to be included as co-authors for standard fee-for-services. For collaborative projects that merit co-authorship, BAHTL staff will work with you more extensively on data interpretation and project scope. For any work that develops as a collaboration, we will be available to contribute input on data interpretation and modeling approaches throughout the project including on scientific presentations and publications.

COVID-19 Related Contingencies and Policies

Our lab is operating under sustained but reduced capacity during the pandemic. Both Dr. Fosdick and Dr. Goldsmith are classified as essential University of Connecticut infrastructure employees, and they have maintained access to the analytical facilities during university and state closures. We are approved to conduct scientific research during Phase 2 university re-opening, which allows us to carry out routine analytical research following protocols that prioritize the health and safety of our personnel and community. Our ability to host on-site lab visitors has been limited by these restrictions. However, we are working with visitors on a case-by-case basis to assess the optimal strategies to support educational and scientific endeavors while maintaining health and safety of our visitors and staff. Alternative approaches include virtual tutorials, trainings, and instrument monitoring during real-time data collection.