

EarthScope Student Geochronology Research and Training Program Laboratory Overview

University of California, Santa Cruz
(U-Th)/He and LA-ICP-MS U-Pb Laboratories

(U-Th)/He Thermochronology

The UC Santa Cruz was established in 2007 for routine (U-Th)/He dating of apatite, zircon, and monazite by Prof. Jeremy Hourigan. The helium extraction facility utilizes complementary multi-user, open-access ICP-MS analytical facilities in the Institute for Marine Sciences and a new ThermoScientific Apreo Scanning Electron Microscope with multiple detectors including cathodoluminescence. Hourigan maintains strong collaborative ties with the Stanford Thermochronology Laboratories supervised by Marty Grove and others; thus, we would welcome research that spans these complementary laboratories.

Mineral Separations. The mineral separations lab maintains: (1) a Marcy jawcrusher; (2) a Bico disc mill; (3) a Gemeni water table; (4) a Frantz Isodynamic magnetic separator; and (5) glassware and consumables for lithium metatungstate ($\sim 2.8 \text{ g/cm}^3$) and methylene iodide ($\sim 3.3 \text{ g/cm}^3$) density separations. Acids for pyrite removal and a “wig-I-bug” for barite removal are available. Given the time-intensive nature of mineral separations researchers are strongly encouraged to complete this work prior to their visit.

Aliquot Characterization. Two Leica binocular picking scopes with eucentric rotating polarizing stages allow simultaneous grain selection. Grain morphometric analysis is achieved using a Qimaging 5MP camera on the Leica MZ16 scope. Custom LabVIEW code streamlines measurements described in classic alpha ejection papers, and streamlines systematic archival. Grains are packed in Nb foil under reflected light and loaded into 51 well planchettes with hot blanks and standards.

Helium Extraction and Measurement. The helium extraction line employs a custom-built 980 nm diode laser with IR-pyrometer-based feedback for total gas and step-heated diffusion experiments. Continuous ramp heating analysis is in a testing phase. Combined thermocouple-pyrometer feedback laser diffusion experiments utilize an 8-sample diffusion cell. Gas is purified with an ST-172 getter, and then concentrated and further purified with a Janis cryogenic trap. Helium intensities and molar contents are measured with a Pfeiffer Prisma quadrupole residual gas analyzer with a channeltron electron multiplier using pipetted 4He and spike 3He aliquots from a ~ 4 -litre calibrate tanks. Analysis is fully automated with custom LabVIEW code developed in house.

U-Th-Sm analysis. Mineral digestion occurs in the WM Keck Isotope Laboratory. We maintain mixed ^{236}U - ^{229}Th and Sm spikes, gravimetrically calibrated U-Th solutions for spike U,Th, Sm content calibration and a broad suite of acid stills, teflon labware, digestion vessels and ovens for sample digestion. A Thermo X-Series II ICP-MS equipped with an ESI SC-FAST autosampler is used to measure U,Th, Sm content as well as “survey scans” across the periodic table.

Zonation. For strongly zoned zircon samples laser-ablation depth-profile characterization is recommended. A laser ablation system coupled to a quadrupole mass spectrometer is used for quantitative concentration analysis. The lab maintains a suite of in-house and community concentration and isotopic standards for this application. Drilling rate calibration experiments for conversion of time series into depth series utilize a Zygo NewView 7200 vertical-scanning white light interferometer.

Laser Ablation ICP-MS U-Pb analysis

The Institute for Marine Sciences Plasma Analytical Facility consists of: (1) Thermo iCAP-OES, (2) Thermo X-Series II; (3) Thermo ElementXR; and (4) a Photon Machine Analyte Excite 193nm excimer laser ablation system. Mount preparation is completed in the Helium Laboratory. For detrital analysis we typically mount 10 unknown samples and 4-5 standard samples on each 1" round. Indium and sticky-tape mounts are also possible. Targeting is streamlined with LabVIEW-based middleware. Users can expect a standard 10 sample mount to take <2 hours to target and 22 hours to run (1000 unknowns / 400 standard). Middleware records analysis location on detailed mount mosaics or CL images. Data are processed with lolite 3.5 and transferred to IsoplotR for plotting with custom designed middleware.

Time Frame (U-Th/He): Users can anticipate a 1-2 month lead time before the lab's schedule can accommodate a (U-Th)/He project. At a minimum, students/researchers should plan to spend 2 weeks in Santa Cruz. Those with access to a binocular picking scope can limit time away from their home institution by down-selecting high-quality minerals prior to arrival. During their time in Santa Cruz students will create their own data reduction programs either in Excel or a scientific computing language of their choice; students fully engaging in their own data reduction will ensure understanding of all phases of data production. Final, publication-ready data reduction will be completed with in-house software. **(U-Pb)** Lab and Hourigan's schedule permitting, users can usually schedule a visit with a 1-month lead time. For every 10 detrital samples, researchers should budget 3 full days - 1 day each for mount preparation, analysis and data reduction. Students should come to Santa Cruz having read lolite papers and - guided by UCSC lab videos - worked through some trial datasets in the free version of lolite.

Analytical Costs. The (U-Th)/He lab operates on a cost recovery basis. Present rates for collaborative external recharge work are \$30/grain for apatite and \$40/grain for zircon. We recommend 7 aliquots per sample of apatite and 5 aliquots for zircon. Thus, applicants should budget \$210/sample for apatite and \$200/sample for zircon. Laser Ablation ICP-MS work in the Plasma Analytical Facility is billed at \$50/hour for LA-ICP-MS. Users should budget 2.5 hours of time per 100 analysis detrital sample, with ~35 intercalated primary and secondary standards. Thus a 10 sample detrital project would cost \$1200. CL imaging analysis bills out at \$50/hr, 10 sample mounts are imaged at high resolution in 2.5 hours.

Personnel. The UCSC Helium Thermochronology operates with no permanent technical staff. The Plasma Analytical Facility is staffed by a 100% Instrument Specialist who oversees functionality and internal training, but is not responsible for analytical training of external users. Hourigan maintains the helium line and is responsible for training students in all aspects of mineral separations, (U-Th)/He and U-Pb analysis. Thus, the capacity to conduct AGeS2 work is limited to one (U-Th)/He project and several U-Pb projects per year, ideally on themes and regions that complement other active research in the laboratory.

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