Group 18 Laboratories, School of Earth and Space Exploration, Arizona State University

Laboratory Description

The Group 18 Laboratories at Arizona State University, named for the group in the periodic table of the elements that includes the noble gasses, provides opportunities for ASU and external researchers to incorporate $^{40}Ar/^{39}Ar$, (U-Th)/He, and U/Pb geochronologic and thermochronologic data into a wide variety of earth and planetary science research projects. Projects requiring $^{40}Ar/^{39}Ar$ constraints on the crystallization ages of volcanic materials or the cooling histories of K-bearing minerals from bedrock or detrital sedimentary samples take advantage of one of two gas extraction systems fitted to a multicollector, gas-source mass spectrometer (Nu Instruments *Noblesse*). One is a diode laser-heated furnace, with thermocouple-enabled temperature control for detailed incremental-heating experiments; the other is a CO_2 laser heating and fusion system for single-crystal fusion, as well as incremental heating experiments involving progressive increases in laser energy where direct temperature control is unnecessary. A second $^{40}Ar/^{39}Ar$ system – comprising another multicollector Noblesse instrument and an ESI/New Wave 193nm ArF excimer laser microprobe – can be used for high spatial-resolution dating of terrestrial, lunar, and meteoritic samples in polished sections or grain mounts. Conventional, single-crystal (U-Th)/He dating of apatite, monazite, rutile, titanite, xenotime, and zircon can be done using an ASI *Alphachron* analytical system, which comprises an infrared diode laser for gas extraction and a small quadrupole mass spectrometer for helium measurements. Samples are subsequently digested in acids and spiked for isotope dilution Sm, Th, and U analysis with a Thermo *iCap Q* plasma-source quadrupole mass spectrometer. In addition, we are the only laboratory in the United States that routinely does laser microprobe (U-Th)/He analyses of the accessory minerals zircon, titanite, and apatite. Such analyses involve the use of a second (Photon Machines) 193nm ArF excimer laser microprobe, a GV Instruments *Helix SFT* magnetic sector mass spectrometer for helium measurements, and the *iCap Q* for Sm, Th, and U analysis by laser ablation inductively coupled, plasma-source mass spectrometry (ICPMS).

Types of Projects We Support

Although we offer access to the Group 18 Laboratories for many types of projects that require noble gas and (U-Th)/Pb geochronologic and thermochronologic data, we are especially well-positioned to support studies of the bedrock cooling histories of igneous and metamorphic landscapes and studies of detrital minerals in ancient sedimentary successions and modern river sediments. Our laboratories are unusual in that we can support multichronometric studies. For example, users of the facilities who want to better understand the thermal history of a specific granodiorite might – with appropriate separated minerals – undertake U/Pb geochronology of zircon or monazite to constrain the granite's crystallization age, as well as U/Pb, $^{40}Ar/^{39}Ar$, and (U-Th)/He thermochronometry of a wide array granitic minerals, *all in the same laboratory complex using a self-consistent set of analytical and data-collection protocols*. We also specialize in multichronometric analyses of detrital materials using laser fusion techniques for $^{40}Ar/^{39}Ar$ work and laser ablation techniques for U/Pb and (U-Th)/He work. A unique aspect of the Group 18 facilities is our capacity for routine U/Pb and (U-Th)/He "double dating" of individual detrital accessory minerals.

Preparations and Expected Time Frame

$^{40}Ar/^{39}Ar$ studies require especially extensive preparation before the analytical work can begin. First, the visiting researcher must produce high-purity mineral separates of the target materials or a doubly polished thick (ca. 300 micron-thick) section of a sample. Polished sections must not be prepared using standard epoxy or vacuum impregnated with epoxy; call ahead before preparing samples to establish a workable protocol. For separates, we recommend the separation of at least 50 mg of the target mineral with a grain size of no less than 250 microns. From the date that these materials are received by us, roughly six months of time will be required before the samples are analyzed in order to have them

irradiated and then become safe for laboratory handling. Students who want to visit the laboratories during analysis and data reduction are encouraged to do so, but it is impractical to allow the visitors to actually run the samples themselves because of the necessary radiation certifications.

Typical lead times for (U-Th)/He dating are 3-4 months depending on the complexity of the project. The visitor again is expected to prepare high-purity mineral separates themselves, but the hand-picking of individual crystals for analysis can be done in the Group 18 Laboratories by visiting students. We ask that, when possible, the visiting scientist will pick at least 10 grains per bedrock sample and 150 grains per detrital sample, and a fraction of those will be selected for analysis. Picking for conventional (U-Th)/He work can be done just prior to analysis, but picking for detrital work will require a separate trip because roughly a month will be required between when the grains are separated until they can be analyzed due to the time required for mounting and characterization of the grains by backscattered electron or cathodoluminescence mapping. We do not normally permit outside users to do mineral dissolutions or laser ablation work unsupervised due to the need for additional certification by laboratory safety and radiation professionals at the university.

Analytical Costs for Academic Users (Internal and External)

$^{40}Ar/^{39}Ar$ Dating of Bedrock Samples

Incremental heating analysis of a single mineral (assumes a nominal 10 steps)	$ 550
Total fusion analyses of 10 crystals from a single volcanic sample	$ 550
Additional increments or additional fusions, each	$ 55
Laser microprobe work on polished section; price per ablation analysis	$30

$^{40}Ar/^{39}Ar$ Dating of Detrital Samples

Total fusion analyses of a population of one mineral in a sample (ca. 100 dates)	$1000

Conventional (U-Th)/He Dating of Bedrock Samples

Apatite crystals (per grain, 5 grains per sample recommended) from a single sample	$ 60
Titanite crystals (per grain, 5 grains per sample recommended) from a single sample	$ 75
Zircon crystals (per grain, 5 grains per sample recommended) from a single sample	$ 90

Prices for other minerals determined on a per case basis.

Laser Ablation (U-Th)/He and U-Pb of Detrital Samples

Imaging cost (backscattered electron or cathodoluminescence of a mount of many crystals)	$150
Titanite or Zircon analytical cost, per grain (ca. 100 dates per sample recommended)	$ 25

Laser Ablation U-Pb of Detrital Samples Only

Imaging cost (backscattered electron or cathodoluminescence of a mount of many crystals)	$150
Titanite or Zircon analytical cost, per grain	$ 6

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