

EarthScope Student Geochronology Research and Training Program Laboratory Overview

Electron Microprobe and Tephrochronology Laboratory at Concord University

Overview of Tephrochronology

Tephrochronology is an age-equivalent dating method which uses tephra beds as isochrons. Where the age of a tephra layer is known (e.g. from historical eruption records, layer counting, or radiometric dating), this age may be imported into any sequence where that tephra is found. Where the same tephra layer(s) are found in multiple locations, tephrochronology may also be used to test the synchronicity of events at a precision exceeding that of most radiometric methods, even if the exact age is uncertain. With the advent of cryptotephra studies, such isochrons may span very long distances, sometimes thousands of kilometers, allowing direct links between terrestrial, lacustrine, marine, and ice core records. Tephra beds are commonly employed to provide age control in paleoseismic, paleoenvironmental, and volcanic studies among others. Tephra beds are typically identified to specific eruptive events and correlated between locations using major element glass chemistry obtained by electron probe microanalysis (EPMA). In some cases this may be supplemented by glass trace element and/or mineral chemistry to obtain a definitive identification.

Laboratory Facilities

Concord University's EPMA lab contains an ARL SEMQ electron microprobe configured with six wavelength-dispersive (WDS) spectrometers, secondary and backscatter electron imaging detectors, and a large-area 30 mm² silicon drift detector (SDD) energy-dispersive (EDS) spectrometer. Beam current is regulated, and current drift is typically less than 0.5% over 12 hours. The instrument has been substantially refurbished and upgraded and is under service contract. It is installed in a 440 square foot, bottom-floor laboratory with dedicated climate control to enhance instrument stability.

Automation is provided by Probe for EPMA (Probe Software Inc.) and Esprit (Bruker). Probe for EPMA provides for routine automation of WDS quantitative analysis. Regularly used software features for glass analysis include mean atomic number (MAN) modeled X-ray background intensities, time-dependent intensity (TDI) correction (essential for alkali element migration in glasses), quantitative interference corrections, trace-element blank corrections, and combined WDS+EDS analysis to enhance both accuracy and precision. Bruker's Esprit software provides for automated EDS analysis, digital imaging, and EDS + WDS X-ray mapping.

Analytical work is supported by a collection of more than three hundred reference materials including metals, glasses, minerals, and synthetic compounds. Tephrochronology studies are further supported by an extensive collection tephra reference samples.

Raw analytical data is originally recorded on the EPMA automation computer. The complete raw WDS X-ray intensities and EDS spectra are saved for every individual analysis, and these may be reexamined or reprocessed at any time. Data are backed up both onsite (nightly via an incremental backup server) and offsite (in real time to a 1 TB DropBox account which also facilitates sharing of data files and folders with clients and collaborators).

The EPMA lab is supported by a suite of sample preparation equipment. This includes rock saws, sieves, ultrasonic bath, hot plates, heavy liquids, thin section equipment, sample polishing equipment, and a carbon coater. These are further complemented by petrographic microscopes and a high-resolution flatbed scanner capable of full thin section scans under both plain and polarized light.

Preparation for a Visit

Students should have collected several tephra samples. These may be from visible tephra deposits or invisible glass shard accumulations in sediments (cryptotephra). Contact the lab for advice regarding sample collection and documentation. In most cases, students can schedule a visit with 1-2 months lead time.

A Typical Visit: Sample Preparation, Analysis, and Data Evaluation

Most analytical work done in the laboratory is performed by students. So, we are well prepared to train and supervise new users. We have hosted visits by undergraduates, graduate students, and faculty. Training and supervision is typically provided by Dr. Kuehn, Director of the laboratory.

Students may prepare their samples on site or in advance at the student's home institution. Preparation typically includes an ultrasonic bath, wet sieving, drying, epoxy mounting in an acrylic disc, polishing, and carbon coating. Samples containing carbonates or with a high organic content may require treatment with 10% HCl or 10% H₂O₂ respectively prior to other steps. Cryptotephra glass samples and mineral concentrates (if desired) typically require heavy liquid separations using lithium polytungstate solutions.

Typically a small set of glass-rich tephra samples may be prepared one day and analyzed the next. Cryptotephra samples and mineral separates require additional time. A typical one-day analytical session for tephra glass will include (1) 12-element analysis of a set of four standard reference glasses in the morning, (2) analysis of a series of unknowns from late morning through early evening, and (3) analysis of the same reference glasses again in the evening to close out the session. Typically, 3 to 8 tephra samples may be analyzed in a single analytical session. Post-processing of the results in Excel, searching databases for potentially matching samples/eruptions, and evaluating each candidate can take place the following morning. If desired, backscatter electron images of glass shards may also be collected. In total, a modest set of glass-rich samples with all work done on site could be completed in a 3-4 day visit. Students will receive training and assistance in all aspects of the process during their visit.

Analytical Costs

Typical laboratory rates for new visitors doing tephra work include a \$300 training fee, \$10/sample for consumables used during sample preparation, and \$30/hr for beam time on the instrument (up to a daily maximum of \$300). It may be possible to negotiate analytical costs for EarthScope student projects depending on the specific project needs and details. So, please contact us in advance as you are planning your project. For comparison purposes, our typical commercial rate (with our staff doing the preparation, analysis, and data evaluation) is \$300/sample.

Laboratory Contact

If you are interested in acquiring data in our lab for a tephrochronology project, or would like to discuss potential collaborations, please contact:

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