Tephrochronology

Concord University
EPMA and Tephra Lab

The Electron Microprobe and Tephra Laboratory at Concord University (Athens, West Virginia) specializes in providing geochemical data for undergraduate and graduate student research. In fact, the vast majority of analytical work and sample preparation is done by students. The laboratory fully embraces justice, equity, diversity, and inclusion as a core principle.

The EPMA and Tephra Lab is well-equipped to handle samples of visible tephra deposits as well as cryptotephras. Three specialized analytical routines for volcanic glasses provide data for major-minor elements and a few of the more abundant trace elements across the spectrum of mafic to felsic and alkaline compositions. Fine, pumiceous, and microlitic grains can be analyzed with a beam spot as small as 4-5 microns while retaining excellent accuracy for sodium. An additional method provides Fe-Ti oxide data for cases where glass compositions alone are not sufficient for eruption identification. Another routine provides for analysis of trace Ti in quartz with an 8 ppm detection limit.

What is Tephrochronology?

Tephrochronology is an age-equivalent dating method which uses tephra (volcanic ash and pumice) deposits as isochrons. Where an eruption age is known, this age may be imported into any depositional environment where that tephra is found. Tephra correlation may also be used to provide chronologic tie points and test the synchronicity of events at a precision exceeding that of most direct radiometric methods, even if the exact age is uncertain. By using both visible and cryptotephra deposits, such isochrons allow direct links between terrestrial, lacustrine, marine, and ice core records across thousands of kilometers.

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.

Analytical Facility

Concord University's EPMA lab contains an ARL SEMQ electron microprobe configured with six wavelength-dispersive (WDS) spectrometers, a large-area 30 mm^2 silicon drift detector (SDD) energy-dispersive (EDS) spectrometer, a secondary electron imaging detector, a high-sensitivity backscatter electron detector, and a vibration isolation platform. Beam current is well-regulated, and drift is typically less than 0.5% over 12 hours. Multiple upgrades provide better than new instrument performance. The electron microprobe is installed in a 440 square foot, bottom-floor laboratory with dedicated climate control for optimal stability.

Automation is provided by Probe for EPMA (Probe Software Inc.) and Esprit (Bruker) running on Windows 10. Software features regularly used for glass and mineral analysis include mean atomic number (MAN) modeled X-ray background intensities for greater precision, time-dependent intensity (TDI) corrections for accurate sodium and potassium concentrations, quantitative spectral interference corrections, trace-element blank corrections, and combined WDS+EDS analysis. A collection of more than 300 reference materials including metals, glasses, minerals, and synthetic compounds supports instrument calibration and routine quality control.

Sample Preparation Facility

The EPMA lab is supported by a suite of sample preparation equipment. This includes stainless steel sieves, plastic mesh sieves, ultrasonic bath, hot plates, Nd magnets, and lithium polytungstate heavy liquids for tephra and cryptotephra sample processing. Epoxy molds, thin section equipment, sample polishing equipment, and a carbon coater are used to mount and prepare samples for analysis. 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 an On-Site Visit

In most cases, students can schedule a visit with as little as 1 month lead time. Students should have collected several tephra samples for analysis. These may be from visible tephra beds or cryptotephras samples containing trace glass shard accumulations in host sediments. Contact the lab for advice regarding sample collection and documentation. Please also refer to recent tephra community best practice guidance available on Zenodo
https://zenodo.org/record/4075613

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

As most work is performed by students, we are well prepared to train and supervise new student users. We have hosted many visits by undergraduates, graduate students, and faculty. Training and supervision are 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. Visible tephra 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 HCl or H2O2 respectively prior to other steps. Cryptotephra samples and mineral concentrates (if desired) also involve heavy liquid separations.

A small set of glass-rich tephra samples may be prepared one day and analyzed the next. More typically, a student will spend 2-3 days on preparation and 2-3 days on analysis. Cryptotephra samples and mineral separates require additional time. An analytical day on the electron microprobe normally includes a batch of tephra samples bracketed by reference glasses run at the beginning and end of the session. Post-processing of the results in Excel, searching databases for potentially matching samples/eruptions, and carefully evaluating each candidate can take place the following morning. Typically, representative backscatter electron images are collected for each sample to document grain morphology. In total, a modest set of glass-rich samples with all work done on site could be completed in a 3-5 day visit.

Analytical Costs

Costs will depend on the number and types of samples. Our typical commercial rate (with our staff doing the preparation, analysis, and data evaluation) for visible beds is $300/sample . Costs are lower for students doing their own work. Visitors are charged for a portion of staff time (up to $300) and $25/hr for electron beam time (for the first 10 hours, daily maximum $250).

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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