EarthScope Student Geochronology Research and Training Program Laboratory Overview

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Geoluminescence Dating Research Laboratory

The research group associated with the Baylor University, Geoluminescence Dating Research Laboratory (GEOLUM) has over 30 years' experience in developing and applying luminescence dating technology and methods. A focus of this lab is the construction of better constrained chronologies using optically stimulated luminescence (OSL) dating and associated thermal transfer methods that theoretically can date sediment up to 1-2 million years old. In turn, careful application of analytical methods can yield ages on sediments <100 years old. There are numerous exciting research frontiers in the geosciences afforded by the judicious application of luminescence dating. We welcome new ideas and novel planetary applications, computational approaches and technology to further improve and extend this dating method.

The Geoluminescence Dating Research Laboratory (GEOLUM) is housed in a newly constructed (2014) 2000 ft^2 facility within the Dept. of Geosciences at Baylor University. This facility utilizes a variety of luminescence technology including three automated Risø Reader systems; one with single-grain capabilities. The three-current automated Risø TL/OSL readers are used for ultra-small single aliquot, single grain, and thermal transfer-OSL measurements on quartz and feldspar separates. Blue light excitation (470 ± 30 nm) is from an array of 30 light-emitting diodes that delivers approximately 20 mW/cm2 to the sample position at 90% power. A Thorn EMI 9235 QA photomultiplier tube coupled with three 3-mm-thick Hoya U-340 detection filters that transmit between 290 and 370 nm will be used to measure photon emissions. Laboratory irradiations used a calibrated $^{90}Sr/^{90}Y$ beta source coupled with the Risø reader and the experimental sequences were executed using Risø TL/OSL software for MS-Windows.

Our library of software provides flexibility to undertake single aliquot or multiple aliquot analyses utilizing regenerative or additive dose procedures including quartz TT-OSL or feldspar IR-IR290 protocols. We have a full suite of computational software for a variety equivalent dose models that has been recently updated and refined. In addition to mounted and calibrated beta source (^{90}Sr) on Risø Reader, the laboratory maintains four independent calibrated, automated alpha and beta irradiators that provide radiation exposure, for up to 20 samples sequentially, at individually prescribed periods ranging from seconds to hours. These sources have been calibrated to standards at the Laboratory for Art History Archaeology at Oxford University, England and most recently to standards provided by Risø National Laboratory. A bank of eight automated intelligent alpha counters detect total, slow and fast scintillations. Counters are calibrated with uranium and thorium standards supplied by the U.S. Geological Survey. Gamma and a portion of the beta contribution are calculated from potassium analysis of sediment. In lieu of alpha counting most sediment is submitted to ALS Laboratories, Reno, Nevada which provides total, minor and rare earth elemental content by ICP-MS methods. A portable Na–I gamma spectrometer is also available for field measurements.

The laboratory is illuminated by the indirect and diffuse light from sodium–vapor bulbs (590 nm). The intensity of the light is adjusted to prevent resetting of the OSL signal. This facility is equipped with ultrasonic baths; digital scales and precision preheat plates, IEC 2000 centrifuge, a Franz Magnetic Separator, Raman Spectrometer for grain-mineralogy identification and automated grinders for the preparation of a variety of geological materials for luminescence analysis. The Baylor Geoluminescence Dating Research Laboratory has access to electronics laboratory and machine shop within the College of Arts and Science for the maintenance, repair and construction of equipment. Up to $30,000 is provided/year by the College for maintenance and repair of Risø readers. More information about luminescence dating and the Geoluminescence Dating Research Laboratory is at http://www.baylor.edu/geology/index.php?id=868082.

Defining the Research Pathway for the visiting student

Students and other visitors should plan for a 2 to 4 weeks visit, though visitors have arranged longer stays for 1and 2 years to develop deeper collaborations and learning experiences. This visit should be scheduled in advance with Steve Forman (Steven_Forman@Baylor.edu) with discussion of the research goals and time constraints. Initial contact with the student will discuss why OSL dating is needed for a sedimentologic and stratigraphic context and to address a specific geologic or archaeologic question (s). We will evaluate the luminescence geochronologic options and possibility of using other dating techniques options (e.g. ^{14}C dating, U-series dating) to yield the strongest age control, often from multiple geochronometers. There will be extended discussion of the focus of the research and the needed accuracy and precision to test hypotheses or breach new questions. We will discuss with the visitor about the best sampling techniques in the field to retrieve a light-tight samples at the appropriate level and to avoid inhomogeneities in dose rate. The visitor will either post samples to GEOLUM or deliver samples with their arrival. Prior to any analysis the student will need to fill out a sample submittal form, which will be provided and enter their sample (s) into the laboratory logbook (spreadsheet).

Laboratory Orientation

The student will receive an orientation by the Laboratory Director and Laboratory Supervisor. Prior to any lab analysis the student will take a mandatory online-course on Radiation Safety. We will also review all laboratory safety protocols which includes wearing appropriate shoes and clothes, use of a lab coat, protective gloves and face wear; and use of emergency eye wash and shower stations within the lab. The student will shadow a well-experienced graduate student and/or Laboratory Supervisors for 2-5 days, the length of time dependent on proclivities for this type of laboratory work.

Laboratory Approach and Procedures

After the orientation period OSL dating analysis will proceed with 1 or 2 samples to be carefully prepared to isolate the perquisite particle size and mineralogy (quartz or feldspar) for dating. All laboratory procedures will be clearly outlined and monitored initially by the Laboratory Supervisor and Director. There will be ongoing discussion and vetting of data as it is generated. In our lab there is free sharing of data to encourage new ideas and criticism of the analytical approaches, toward analytical improvements. In general, these procedures entail sequentially:

1. Separation of a distinct mineral, such as quartz or potassium feldspar, of a particular particle size, e.g. 100-63 microns. These procedures entail the use of disposal sieve meshes, a non-toxic heavy liquid (sodium polytungstate) and soaking in H_20_2, dilute (12%) HCl and HF always under a fume hood. Students will not be charged with the use of HF, which will be done by the Laboratory Supervisor. It usually takes between 1-2 days to prepare a sample, unless the quartz or K-feldspar content is < 10%, which can lengthen the process to four days.
2. A well-mixed subsample will be collected from the unprepared sample for elemental analysis (U, Th, Rb and K) necessary for calculating dose rate.
3. Grains mounts for petrographic analysis will be completed on unprepared and prepared sample to evaluate mineralogic purity and for selected samples by Raman Spectroscopy.
4. Mounting with silicon spray of 10s of grains of quartz or feldspar to thirty, 9.6-mm-diameter aluminum discs. Then loading these discs on to Risø Reader analysis carousel.
5. Program of Risø Reader analysis for a predetermined experimental sequence for rendering equivalent dose values for each disc loaded.
6. Data processing and statistical analyses to render an OSL age with significant errors.
7. Appropriate data presentation in table and figure form for vetting and publication.

Benefits to student researcher

1. See an active research-orientated geoluminscence dating laboratory with a crew of about dozen students, visiting research scientists and a laboratory supervisor working on numerous projects, worldwide.
2. Learn about radiation and laboratory safety.
3. Gain knowledge about radiation/environmental dosimetry and solid-state physics for OSL dating.
4. Develop a better understanding of the interrelation between sedimentary processes and judicious application of OSL dating.
5. Gain knowledge on OSL dating systematics for equivalent dose and dose rate determinations.
6. Understand the need for high number (> 30) aliquots for equivalent dose determinations.
7. Understand single aliquot and single grain regeneration approaches for equivalent dose determinations. Gain new knowledge on thermal transfer approaches.
8. Become a critical evaluator of OSL data and what analytical paths are needed to increase data quality.
9. Understand the statistical analysis of OSL data and the appropriate use of statistical models.
10. Develop defensible scholarly approaches for presentation and discussion of OSL data and ages; and building better chronologies.

Students should budget $300/sample, which covers all analytical costs, with no additional fees for training.

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