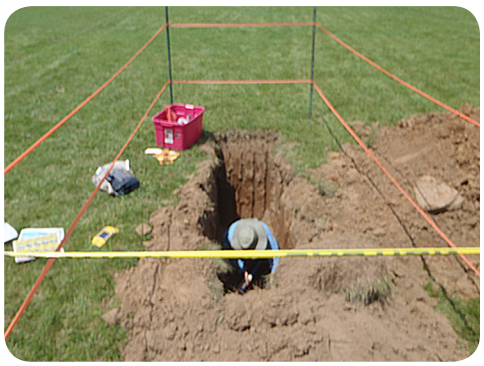
E.L. Cord Luminescence Laboratory

Desert Research Institute

The DRI E.L. Cord Luminescence Laboratory (DRILL) is fully equipped to conduct the latest luminescence techniques and offers a wide range of services for contract work and for research collaboration. The research staff can collaborate on proposals, contribute to grant writing, and consult on study design. We can also arrange training for undergraduate and graduate students, post-docs, and visiting researchers.

What is luminescence dating?

Luminescence dating typically refers to a suite of radiometric dating techniques including Thermoluminescence (TL), in which the signal is reset by heat, and several Optically Stimulated Luminescence (OSL) approaches, in which the signal is reset by light. Over time, with exposure to low level, ambient, ionizing radiation associated with the decay of U, Th, and K electrons become trapped in defects in the crystal lattices of particular minerals. Under stimulation by light or heat, the trapped charges recombine with opposite charges at luminescence centers and release photons of light—the luminescence signal. The intensity of the luminescence signal is proportional to the burial time. The age is calculated as the equivalent dose (the total energy absorbed from ionizing radiation stored in the crystal lattice during burial measured with luminescence techniques), divided by the dose rate, (the annual rate of radiation received per year).



Applications

Luminescence dating is applicable to a wide range of geological, geomorphological, paleoenvironmental, paleoseismological, and archaeological problems. Quartz and feldspar are the primary minerals that are used but other silicate minerals are known to produce a luminescence signal. In the case of sediments, the last exposure to light is dated; in the case of pottery or burnt stones, the last exposure to heat is dated.

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Advantages

Luminescence dating has several advantages including that the minerals making up the sediments themselves are dated rather than some material within the sediment such as organic material or volcanic ash that may not be present within every sample of interest and may be reworked. Unlike radiocarbon, calibration is not necessary. The technique is reliable for dating deposition over a large age range from decades to approximately 200,000 years or more.

CONTACT

Dr. Amanda Keen-Zebert, Director | 775/673-7434
EMAIL: akz@dri.edu

Desert Research Institute
2215 Raggio Parkway
Reno, NV 89512

WEBSITE: www.dri.edu/geochron

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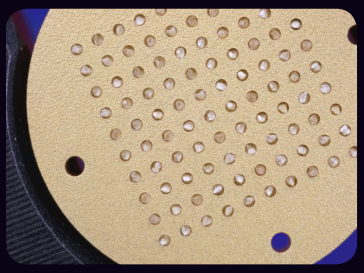
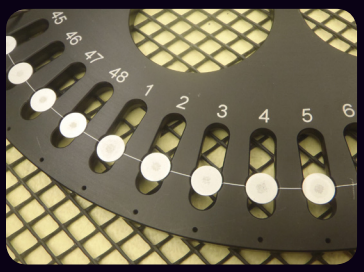
Unopened samples in light-tight sample tubes



Sand grains loaded into a disc for single grain analysis



Multi-grain aliquot discs on the sample holding carousel of the Riso luminescence reader

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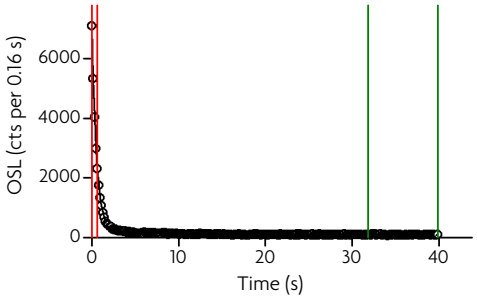
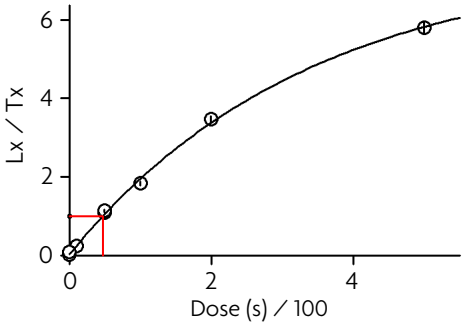
Procedures

Sample preparation involves removing carbonates and organic material from the sample and isolating the grain size and mineral of choice. For coarse grain analysis, hydrofluoric acid is used to etch the outer surface of the grains. Single- or multi-grain aliquots are then mounted on 9 mm stainless steel or Al discs that are placed in a carousel that holds the sample within the luminescence reader. Because there is no absolute relationship between luminescence brightness and radiation dose, each aliquot is calibrated using a radioactive source in the laboratory. The most common procedure used to accomplish this is the Single Aliquot Regenerative dose (SAR) technique. Following the SAR technique, the natural dose is measured, depleting the luminescence signal and creating a decay curve, then multiple controlled increasing doses of radiation are given to the sample and then measured to build a calibration or regeneration curve for each aliquot. Because luminescence sensitivity, the signal per unit of radiation, fluctuates with exposure to heat and repeated bleaching and dosing cycles, the sensitivity is monitored throughout the SAR procedure. Multiple equivalent doses are measured for each sample and then the burial dose is modeled using a variety of statistical age models.



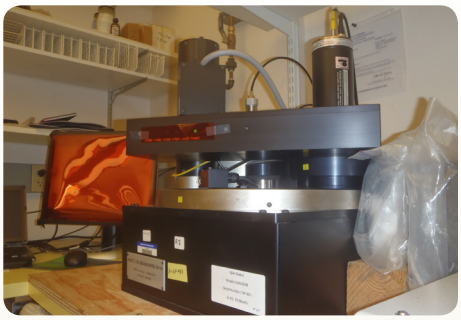
Typical luminescence decay curve



Typical growth curve produced by the SAR method for determining the equivalent dose of a sample

Equipment

The configuration of TL/OSL readers varies by maker, but typically consists of: 1) a photon detector (usually a photomultiplier tube) fitted with detection filters; 2) an irradiator or radiation source; 3) a heater plate; and 4) a light stimulation source fitted with emission filters (for example, blue LEDs for multigrain quartz stimulation, Infrared LEDs for multigrain feldspar, and lasers for single grains).



Analytical equipment and capabilities at the DRILL

The DRILL operates in a dark-room facility equipped to conduct all necessary sample preparations including coarse and fine grained quartz or feldspar separations of sediments or solid objects. Analytical equipment to conduct luminescence measurements includes: 1) a multi-aliquot TL and IRSL Daybreak 1150 Reader; 2) a multi- or single-aliquot OSL/IRSL Daybreak 2200 Reader with an embedded irradiation attachment and a beta (Sr-90) source; and 3) two OSL/IRSL DA-20 Risø TL/OSL Readers both equipped with the latest capabilities including green and IR laser single-grain dating attachments, pulsed-diode and linearly modulated addition capabilities for both blue and IR optical stimulation, and automated beta (Sr-90) and mini X-Ray Varian VF-50JWS (max. 50 kV, 1 mA) irradiation attachments. Supporting equipment includes two automated stand-alone evacuable alpha (Am-241) and beta (Sr-90) irradiators. Dose rates are measured by thick source alpha counting with six Daybreak 582 alpha counters for U and Th content, and by ICP-AES at external laboratories for K content.