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U.S. Geological Survey Luminescence Dating Laboratory
Optically Stimulated Luminescence (OSL) Sampling Instructions

The optically stimulated luminescence (OSL) technique dates the last time sediments were exposed to sunlight or intense heat (think pottery), which zeros the luminescence signal. The luminescence signal grows with time, due to exposure to radioactive isotopes within the sediment and incoming cosmic rays, and thereby is fundamentally different from isotopic methods which decay with time. This is why OSL dating can be used at such a wide range (modern to 500,000 years), depending on the source geology. The age is calculated by dividing the measured luminescence within the sample (how luminescence it already contains) divided by the environmental dose rate (how fast that luminescence was growing in, based on the source geology).

Equipment You Will Need

1. Opaque PVC tubes with a Styrofoam/cloth/plastic/cardboard plug in the sharpened end. You will also need some PVC caps. All can be found at our favorite home improvement stores. A block of wood that can be pounded against the tube will also come in handy. For those with latent engineering tendencies, you can custom make your own extension handle or custom make a cup holder that can be pounded on instead of the actual PVC.
2. Hammer to pound tube into outcrop (a 6 to 12 lb (3-4.5 kg) sledge works best, with the shorter handle) and a hand trowel to excavate a sample for dose-rate.
3. Ziplock bags, quart-sized, good for bulk source sediment sample. Clear "mailing tape", electrical tape or duct tape
4. Tape measure, eye height or good eye to get current depth below landform surface.
5. If the sediment is too hard to drive a tube into, take a block! It's easy and fun. Sampling guidelines below, however you might need black or silver spray paint and aluminum foil.

Optically stimulated luminescence sampling equipment. Credit: S. Mahan, USGS

What You Need to Collect From Each Sample Location in the Field

1. **OSL Tube** filled with sediment, ends capped or taped shut.
2. A **sample for the elemental concentrations/dose-rate of the deposit** from a 30-cm region surrounding the sample tube (put in a Ziplock or plastic bag). It is most easily collected by digging out the sample tube. Please, no more than 600 g per sample! Our sand box back at the OSL lab is already full. Remember that the environment affecting the dose rate constitutes a 3-D sphere surrounding your sample tube, similar in dimensions to a beach ball - so sample accordingly. This means including a representative sampling of the sediment surrounding and behind the sample tube. In most cases half of the sphere is missing because samples are collected from an outcrop.

Optically stimulated luminescence sampling equipment, including: 1) tape, 2) opaque PVC tubes and PVC caps, 3) field notebook to record sampling information, 4) hammer and hand trowel, and 5) measuring tool and plastic bags. Credit: H. Gray, USGS

3. Field water content will be calculated in the lab from your OSL sample. Note on the sample submittal **sheet if the moisture in the sediment collected is representative of the burial history of the sample** (i.e. has the outcrop surface been exposed to drying and therefore the long-term moisture content was higher?).

4. **Depth of burial (in cm or m)** for the cosmic contribution (if there is recent erosion or excavation estimate the pre-erosion burial depth). If the sample was collected from an accumulating landsurface and there are stable land-surface horizons in the stratigraphy (soils), note these also and the burial depth below those past land surfaces -- especially if they are long-lived.
5. The **latitude, longitude and elevation of the sample** (for cosmic contribution).

USGS scientists collecting samples for luminescence dating at Dry Creek, Utah. Credit: R. Briggs, USGS

Optically Stimulated Luminescence (OSL) Sampling Guidelines

1. **Samples must be collected in a light-proof container.** I usually use a pre-sharpened PVC tube that is pounded into the outcrop (only sharpen one end). Others may use metal tubes; you may even hear that metal tubes are better and more light-tight or that PVC is too thick to drive in and shakes too much during sampling (thereby mixing exposed sediment with unexposed sediment). I prefer PVC tubes for four good reasons: it's easier to get the sample out of it when in the lab (sediment slides by the smooth inner walls or if I have to cut the tube I don't require a metal saw), the samples don't rust or adhere to the PVC, there are no sharp metal fragments to cut me in the lab, and tubes are reusable because they can easily be cleaned. Metal tubes are almost always thrown away, thereby wasting precious resources.

   The downside to PVC is that it sometimes shatters if hit directly on the caps (use a block of wood instead) or that PVC may not be light tight if the tube is white (extract under a dark cloth and put directly into a cooler or black film bag). If you are worried about mixing of sediment, I suggest you excavate the outcrop under a dark cloth and start the tube. Then take the cloth down and finish sampling. Does this throw the burden on you in the field so things are easier on me in the lab? Yes. I thank you for the bottom of my unscarred hands and heart.

Sydney Gunnarson sampling for gamma spectrometry at Dry Creek trench, Utah. Credit: R. Briggs, USGS

2. I use 0.5 (1 cm) thin or thinner PVC and this usually has about 1.5-3" (3-8 cm) diameter; white plumbing PVC should be cut to 8" (20 cm) pieces. Additionally, the use of a plug in the end pounded into the sediment will keep the sediment packed during pounding and will further prevent mixing of the sediment from the surface of the exposure (near-zero age) with the target sand at depth.
3. We can date very fine sand (quartz) (90-250 μm typically, 63-250 μm maximum range) or fine silt (4-11 μm) -- deposits that look silty usually have enough of the grain-size needed to date. The deposit or sand lens should be mostly the correct grain size, though. Very coarse sand or anything that looks like you could shape pottery from it may not have enough fine sand to date. If uncertain, bring a sieve into field to check.
4. OSL works best for sediments that are usually older than 40-50 years old. Sediments <50 yrs old commonly do not have enough signal to date and can be dominated by residual signals from partial bleaching (non-complete zeroing of the luminescence signal). However, if the site geology is amenable, very young dating can still be done; check with the OSL lab before sampling (i.e. bricks, high-potassium granites, ceramics, etc.).
5. Use geologic/sedimentologic knowledge! Hillslope deposits also commonly work well for OSL. It is best to see primary sedimentary structures, so avoid bioturbated sediments, soils (modern and paleosols), cracks in the sediment and samples immediately above an unconformity. Bioturbation will cause a mixed signal and will make it much harder to get a real age

from the sediments. Soils have similar problems with mixing, bioturbation, and changes in the dose rate of the deposit. For example, well sorted rippled sands are good, but avoid debris flow deposits. Eolian works best, but fluvial, lacustrine might not retain a linear growth intact of luminescence due to additions or losses of minerals. Sediments immediately above an unconformity may contain material eroded from the underlying deposit that was deposited without adequate exposure to sunlight.

6. It is best to sample from thick deposits/lenses (at least 30 cm thick). Elemental concentrations, and thus dose rate, will vary with heterogeneity of deposit. Avoid sampling near widely different grain-size variations (i.e. clay layer in sand lens) unless you have some way to measure elemental concentrations at the site (i.e. portable gamma spectrometer or portable OSL reader) or wish to take a representative portion of each layer to send to the OSL lab. However, if you have a very thin layer you must/want to sample, you should sample under dark conditions, such as at night or dusk or in a dark tent. If you do have a thin layer to sample, have an old-fashioned film canister (or two or three) and simply excavate back into the layer, filling the canisters with the sample.
7. Avoid sampling <1m below the land surface – due to difficulties in determining cosmic dose rate (and also for reasons below). If it must be sampled "for science" or must be sampled due to outcrop or geological factors (i.e. the next best outcrop has you hanging off a cliff), take detailed notes and hope your OSL lab loves you enough to figure it all out.
8. Occasionally you just have a sample site where the sample is too indurated (carbonate or clay) to drive a tube in without giving yourself a heart attack. We don't want that. To make life as easy as possible, consider the "block approach". Carve a square into the outcrop (or any good spot that requires less effort). Ideally your block will be a 6" square (15 cm). Light only penetrates into sediment about 2-3 cm. By any means possible, get your block. Then take a can of spray paint and spray the block all around. This alerts us in the lab as to what the outside surfaces were (in case the block breaks in transit or after sampling) and it also helps to keep the inner layer as dark as possible. Please, NO RED or GREEN or BLUE paint…under sodium vapor light we cannot tell colors easily, only black or silver can be easily seen! Then wrap your prize in aluminum foil and whatever else you deem necessary…as long as the block gets to us in reasonable shape we don't care what covers it.
9. Make sure the tube is packed tight -- any shaking of the sediments in the tube will cause the outer sediments, exposed to light during sampling, to be mixed with the non-exposed sediments. If there is extra space at the end of the tube, pack with something to make sure the sediments don't move and mix. Don't pack empty ends with sand (du-oh!) as we won't know that this was added to the tube and was not part of the sample.
10. Give samples good individual labels. We get too many labeled OSL 1, OSL 2 or L1, L2 --- these can get confused in the lab. Try using the date of the sampling (i.e. 8/14/12-1, 8/14/12-2, etc.), your initials, or site name and the year (i.e. RTF12-OSL1, RTF12-OSL2, etc.). In the lab, the simpler the better (we have had samples come in with complex labels). Complex labels will be relabeled or given a USGS ID number.

Finally, good luck and hope for good weather!

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Lee Amoroso and Shannon Leslie sampling for OSL and cosmogenics at Qya site. Credit: USGS