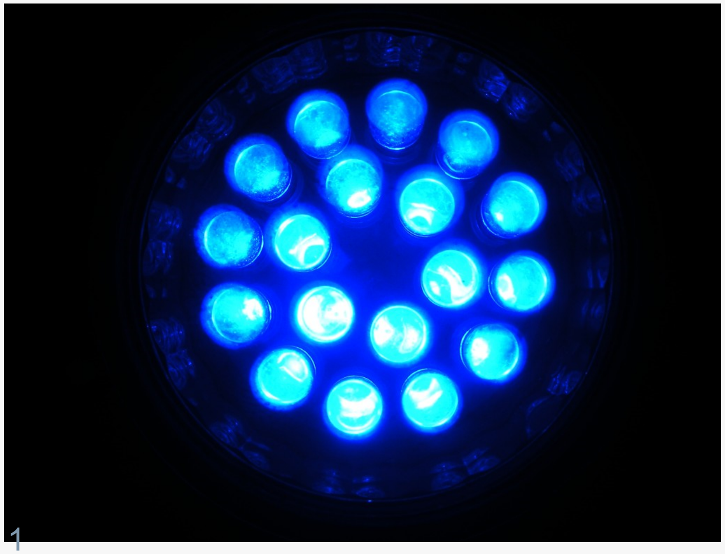
ASSESSING MEASURED EQUIVALENT DOSE DATA AND FREQUENTLY ASKED QUESTIONS ON LUMINESCENCE PROTOCOLS

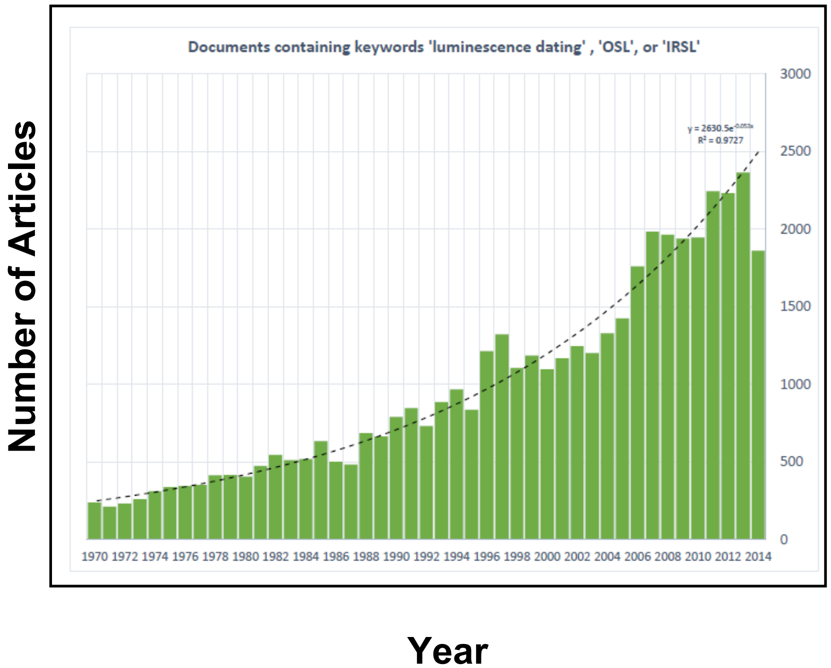
Shannon Mahan, USGS, Denver Colorado

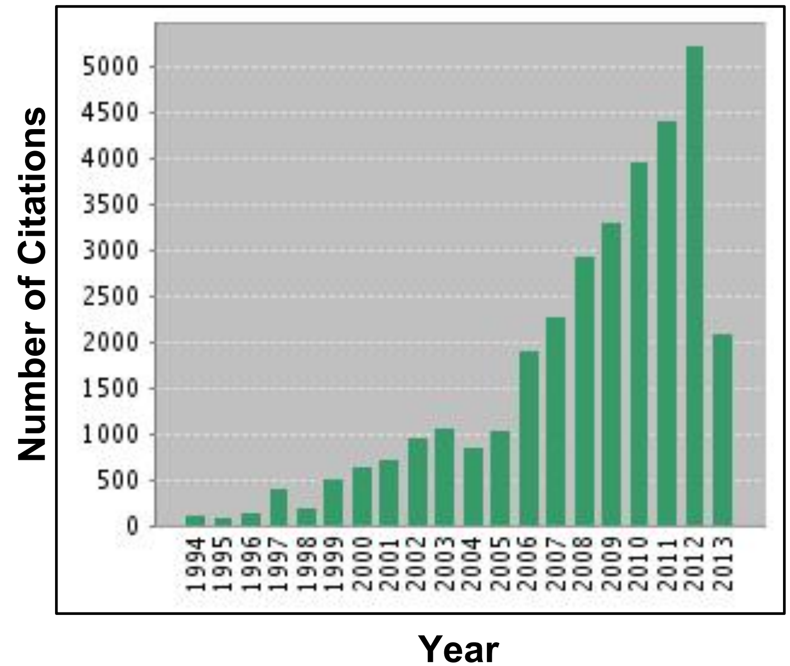
SoSAFE Geochronology Workshop

New geochronologic methods and results from southern California fault studies



Graphs generated from Web of Science on 08/05/13 and 10/25/14
Published Studies Using OSL Dating





FAQ from Reviewers and Users

1. Why is all the emphasis on getting the equivalent dose? (Isn't the dose rate important, too)?
2. What are the problems in quartz OSL dating?
3. What are the problems in K-spar IRSL dating?
4. What new minerals can be used for OSL?
5. What new techniques are in use?
6. What's the resolution of OSL? (Will errors ever get smaller)?
7. Are there calibration standards for OSL in the lab?
8. What is overdispersion?
9. What models do you use and why?
10. How old (or young) can OSL be measured for?

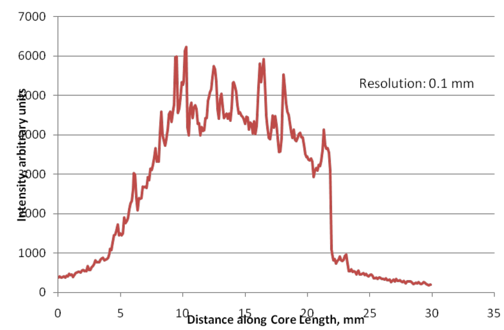
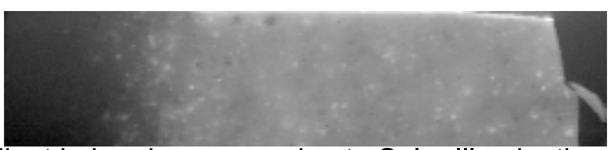
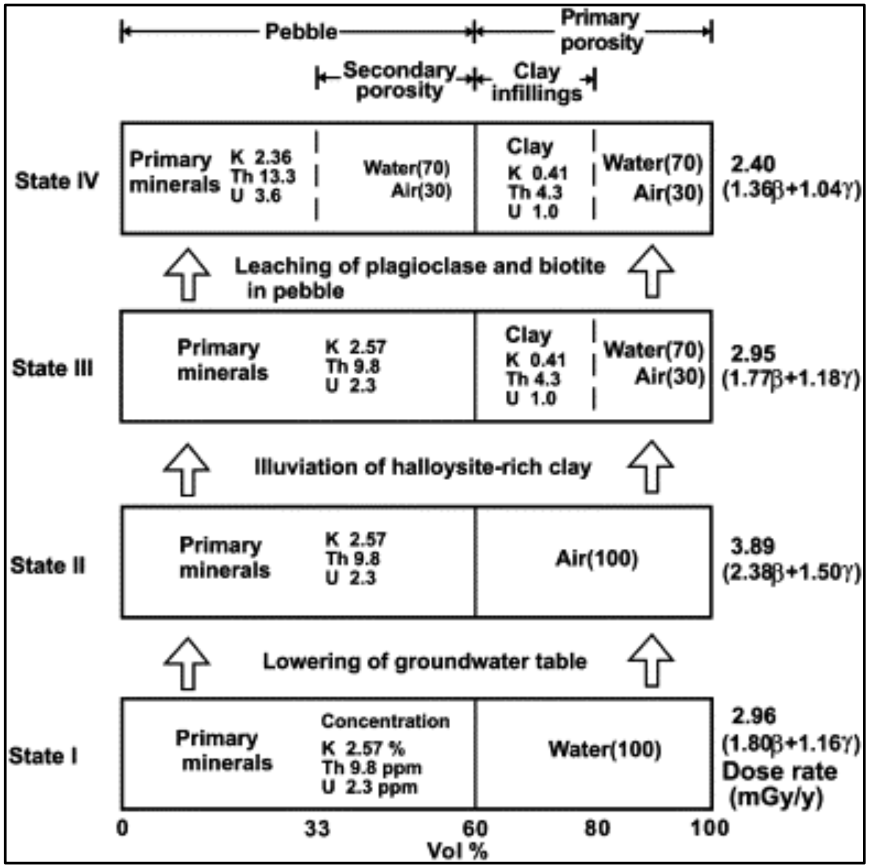


Figure 5: OSL along Length of the Core (illumination from left to right)



Gradient in Luminescence due to Solar Illumination (from left to right)

Importance of dose rate



The #1 problem in determining an accurate dose rate is determining the long-term moisture content of the sediment.

The #2 problem is determining whether there was disequilibrium in the U:Th decay chain at any point due to water flow, sediment disintegration, or soil formation processes (i.e. leaching of feldspars).

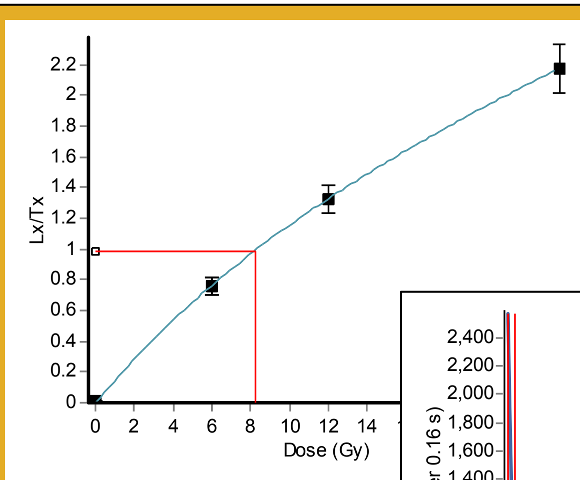
Quaternary Geochronology 2 (1-4) (2007), p. 117-124

Quartz and feldspar differences

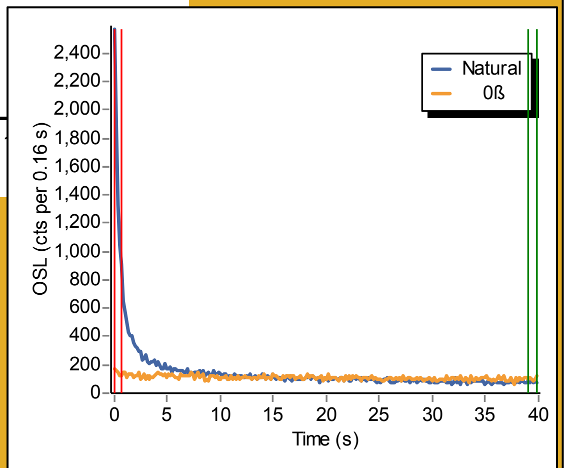
Quartz: Advantage	Quartz: Disadvantage	K-Feldspar: Advantage	K-Feldspar: Disadvantage
Highly resistant to weathering	Relatively low luminescence intensity; some quartz samples do not emit measurable OSL	Luminescence saturates at a higher radiation dose than quartz	Weathers more readily from the environment than does quartz
Luminescence bleaches more rapidly in sunlight than feldspar	Luminescence saturated at lower radiation doses compared to that emitted from feldspar	Luminescence intensity may be orders of magnitude higher than quartz	Suffers from anomalous fading and each sample must be tested and corrected for this
Does not appear to suffer from anomalous fading	Thermal transfer can be higher in quartz than in feldspar	IRSL can be stimulated preferentially in quartz-feldspar mixtures	Difficult or impossible to correct for sensitivity change in regenerative dose data when using SAR
Can produce large and consistent data sets	Sensitivity of quartz due to temperature of crystallization & number of cycles of erosion		

From Lian, Encyclopedia of Quaternary Science, 2007.

Techniques in Use-Continuous Wave single aliquot



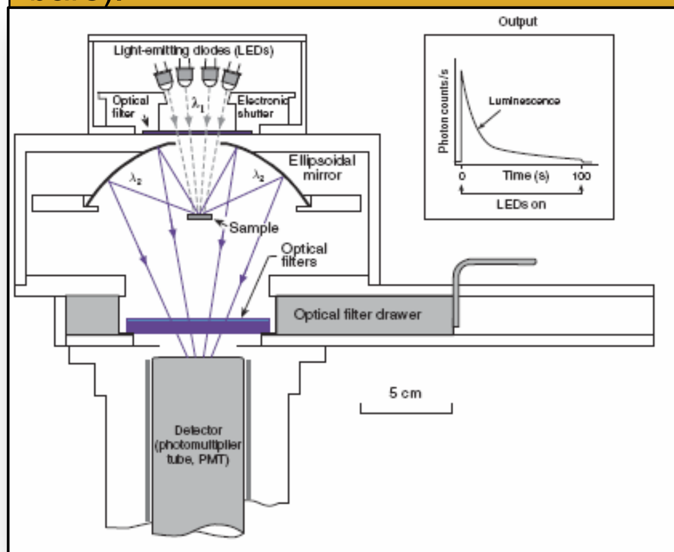
First reference



Continuous-Wave OSL

The OSL equivalent dose data is taken from the initial part of the first 0.5 sec. (red bars).

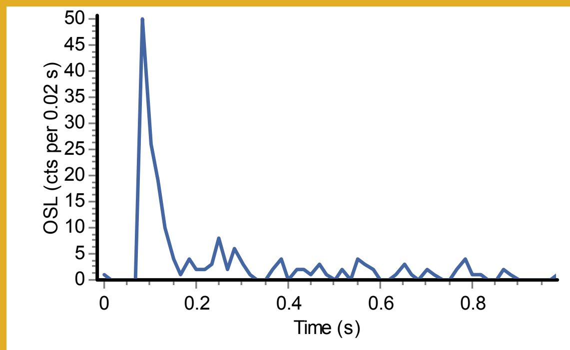
The background adjustment is taken from the last second of the 40 seconds of measurement (green bars).

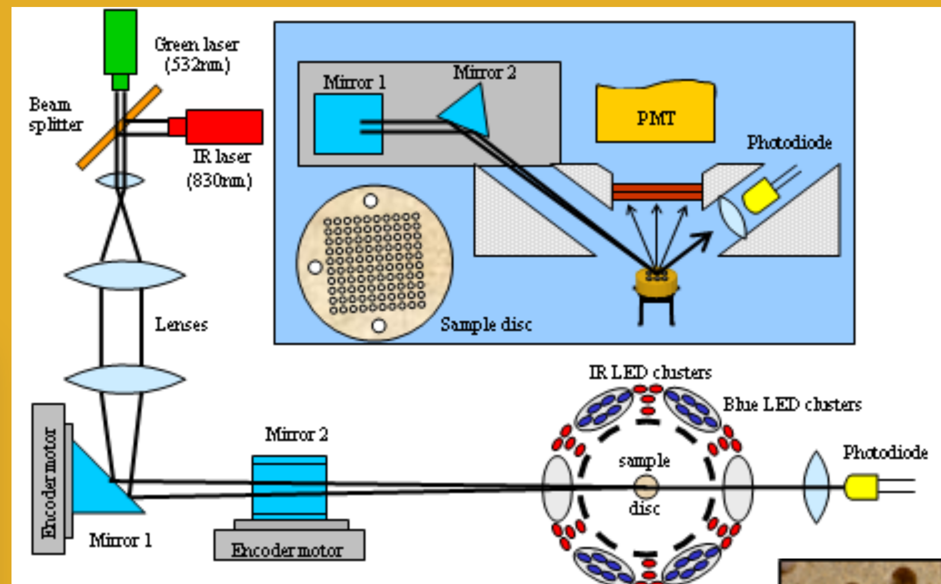


OSL: (can be performed at any elevated temperature)

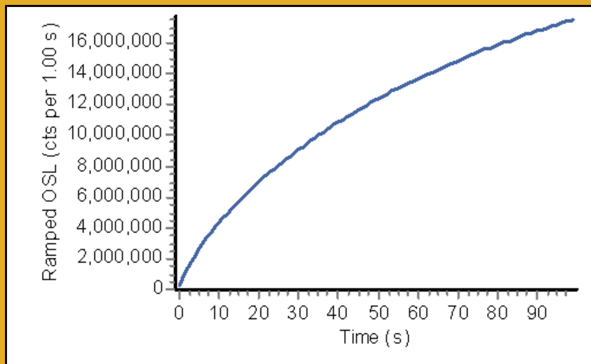
- Blue (470 nm) LED stimulation: 50 mW/cm^2
- Infrared (870 nm) LED stimulation: 145 mW/cm^2

7 Techniques in Use-Single Grain Laser

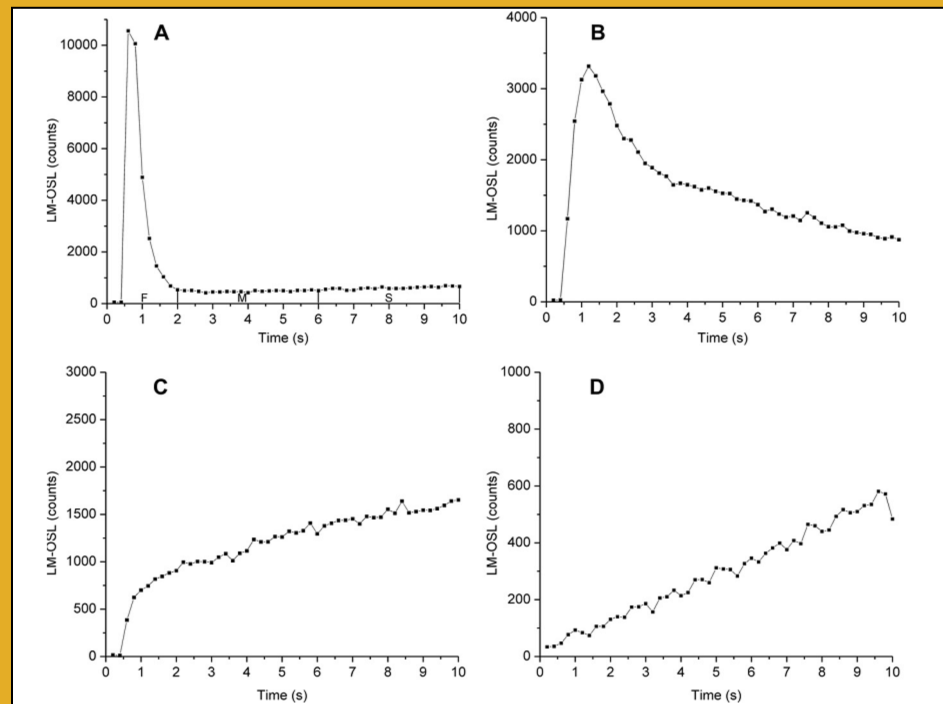




Techniques in Linear Modulation

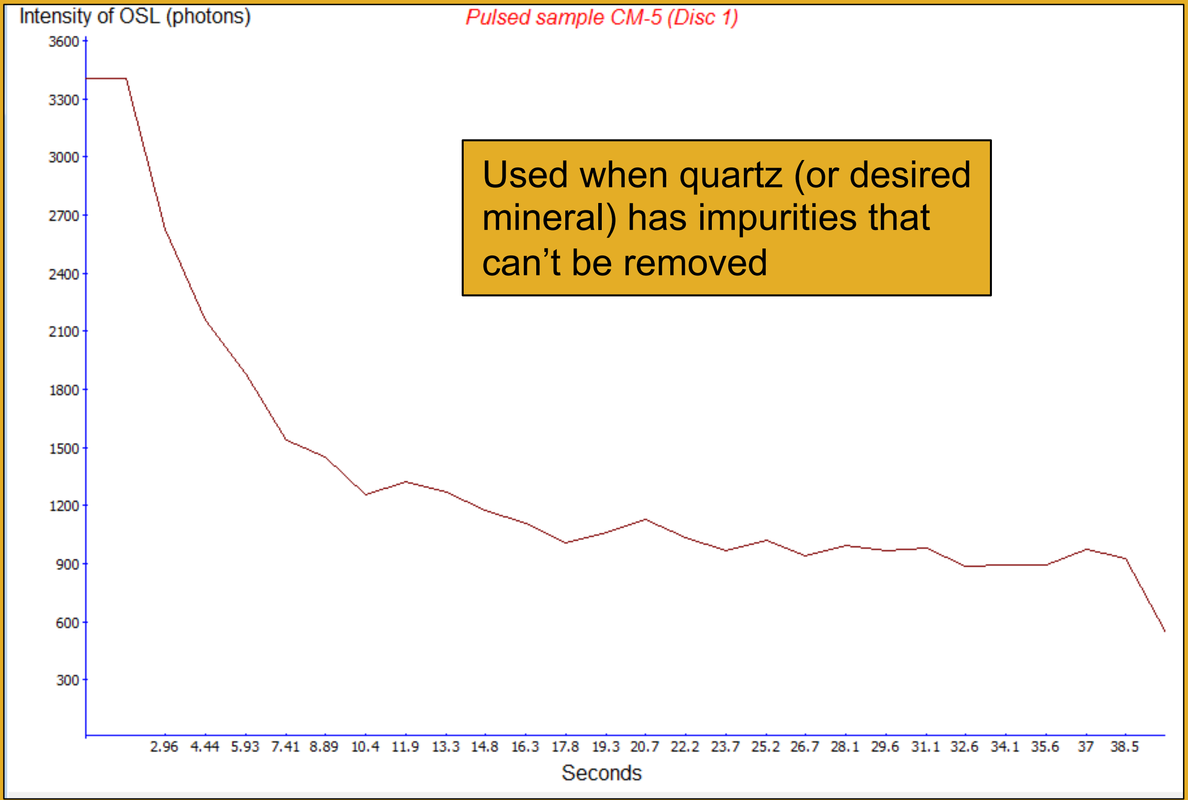


Used when quartz (or desired mineral) has components that can't be separated—the LED's or laser are slowly ramped up. Used for assessing OSL components (e.g. fast, slow, medium).



Quaternary Geochronology 6 (2011), p. 261-272.

Techniques in Use-Pulsed OSL



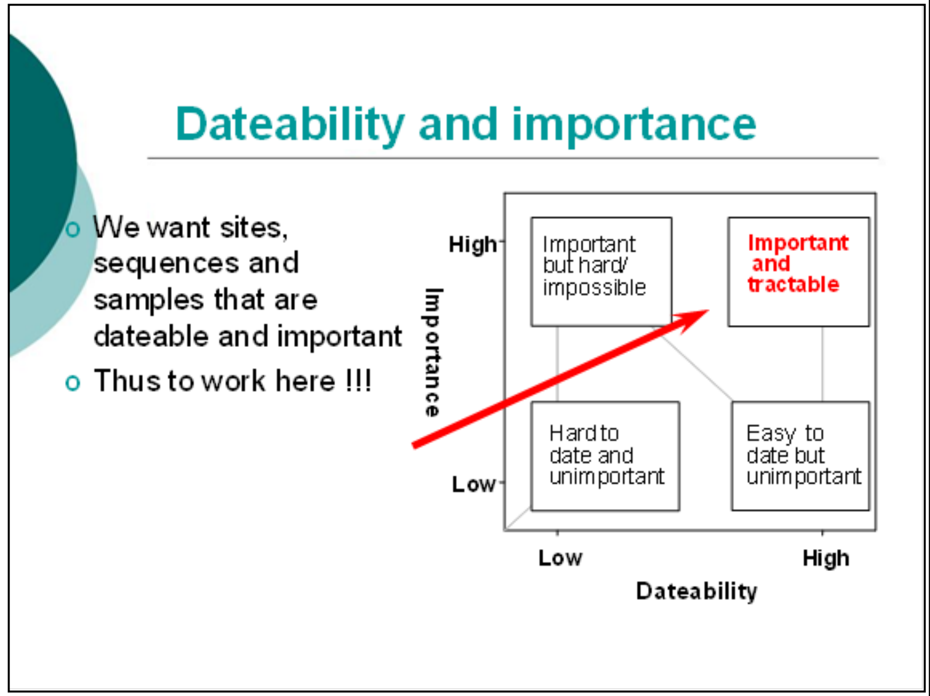
Used when quartz (or desired mineral) has impurities that can't be removed

Radiation Measurements 45 (2010), p. 778-785.

Lower limit determined by detection sensitivity and dose rate data

Upper limit is dependent on source geology (high K, U, and Th means saturation is reached sooner) and stability characteristics of the sample

Some sources of error that are difficult to avoid include conversion from concentration data to dose rate (estimated at ~3%), absolute calibration of concentration measurements (~3%), beta source calibration (~2%), and beta attenuation factor (~2%). These estimated values are of course approximate, **but it should be clear that it is difficult to obtain a luminescence age with an overall or combined standard uncertainty of much less than 5%.**

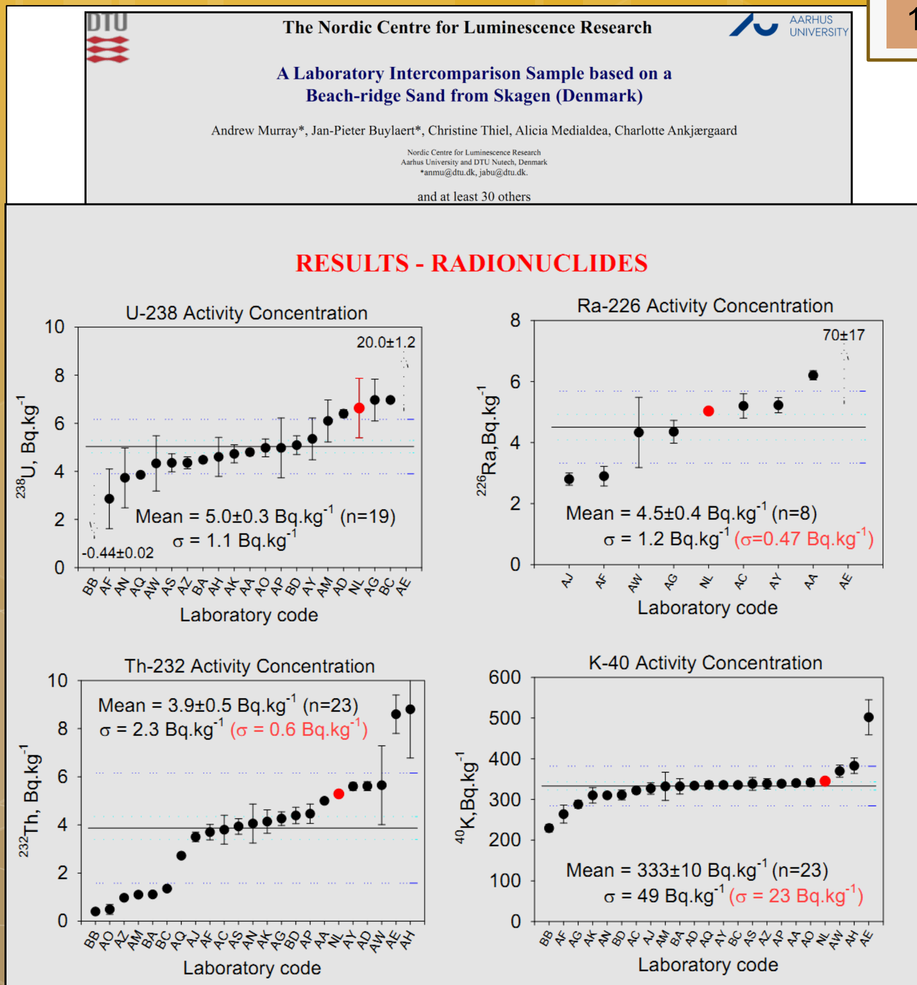


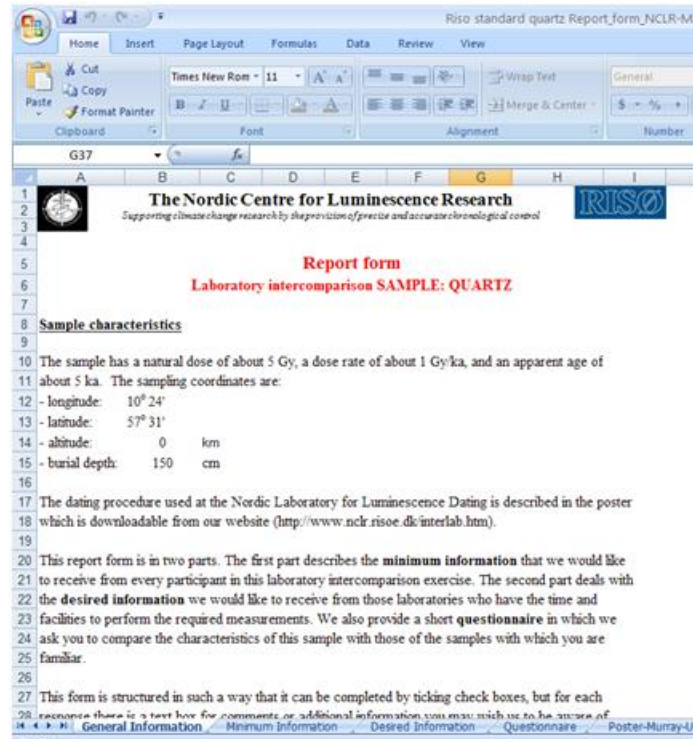
Thanks to David Sanderson, LED11 for permission to use his concept.

Zircon	**Errors remain large due to saturation and linearity problems**
CaCO3	**Includes large spurious signals**
Halite	**Sample preparation is intensive and preheats must be low**
Gypsum	**Bleaching and preheat must be low**
Apatite	**Has extreme fading and requires >500C to drain traps**
Na-Feldspar	**Has extreme fading and requires >500C to drain traps**
Diamonds	**Pre-irradiation with high energy(1-2 MeV electron beam) is an essential pre-requisite for reproducible OSL (mainly radiation dosimetry)**

Use of minerals other than quartz and feldspars for luminescence dating, David Strebler, University of Oxford (Wolfson College). Preset essay submitted for the degree of M.St. in archaeological science, 2013.

12 Riso Labs Calibration Quartz-D_R Results





Riso standard quartz Report_form_NCLR-M

The Nordic Centre for Luminescence Research

Supporting climate change research by the provision of precise and accurate chronological control

RISØ

Report form

Laboratory intercomparison SAMPLE: QUARTZ

Sample characteristics

The sample has a natural dose of about 5 Gy, a dose rate of about 1 Gy/ka, and an apparent age of about 5 ka. The sampling coordinates are:

- longitude: 10° 24'
- latitude: 57° 31'
- altitude: 0 km
- burial depth: 150 cm

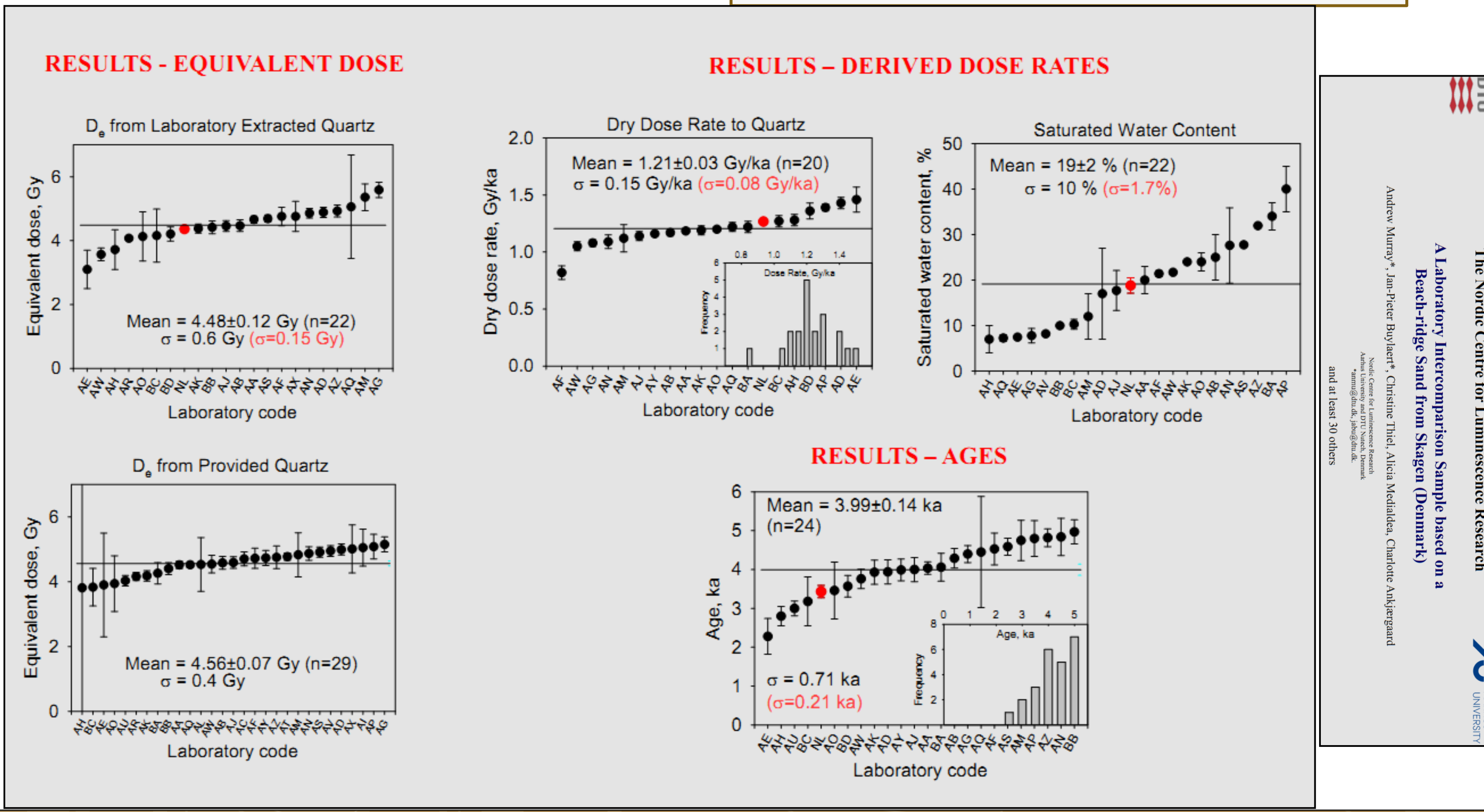
The dating procedure used at the Nordic Laboratory for Luminescence Dating is described in the poster which is downloadable from our website (http://www.nclr.risoe.dk/interlab.htm).

This report form is in two parts. The first part describes the **minimum information** that we would like to receive from every participant in this laboratory intercomparison exercise. The second part deals with the **desired information** we would like to receive from those laboratories who have the time and facilities to perform the required measurements. We also provide a short **questionnaire** in which we ask you to compare the characteristics of this sample with those of the samples with which you are familiar.

This form is structured in such a way that it can be completed by ticking check boxes, but for each

General Information | Minimum Information | Desired Information | Questionnaire | Poster-Murray-U

13 Riso Labs Quartz Calibration-D_E Results



CONCLUSIONS

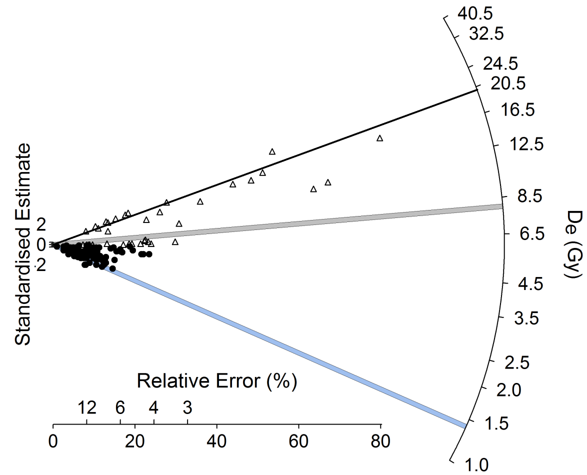
Quaternary Geochronology 11 (2012), 1-27.

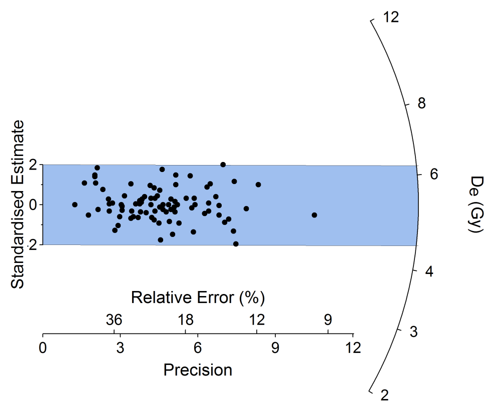
❖Scatter or “overdispersion” is defined as σd, the relative spread in De remaining **after taking measurement uncertainties into account.**

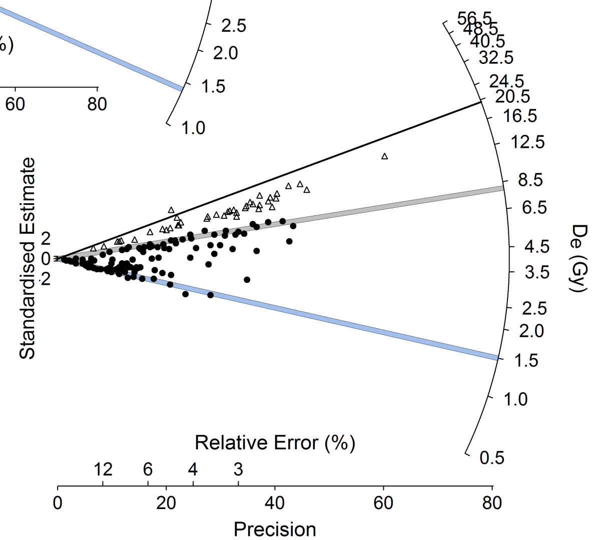
❖In practical terms it is usually accessed or measured by taking the average/standard deviation.

❖A “good” overdispersion is considered anything <20%. Moderate is 25-45% and “bad” is >50%.

❖Some fluvial samples have overdispersion that range from 50-150%.





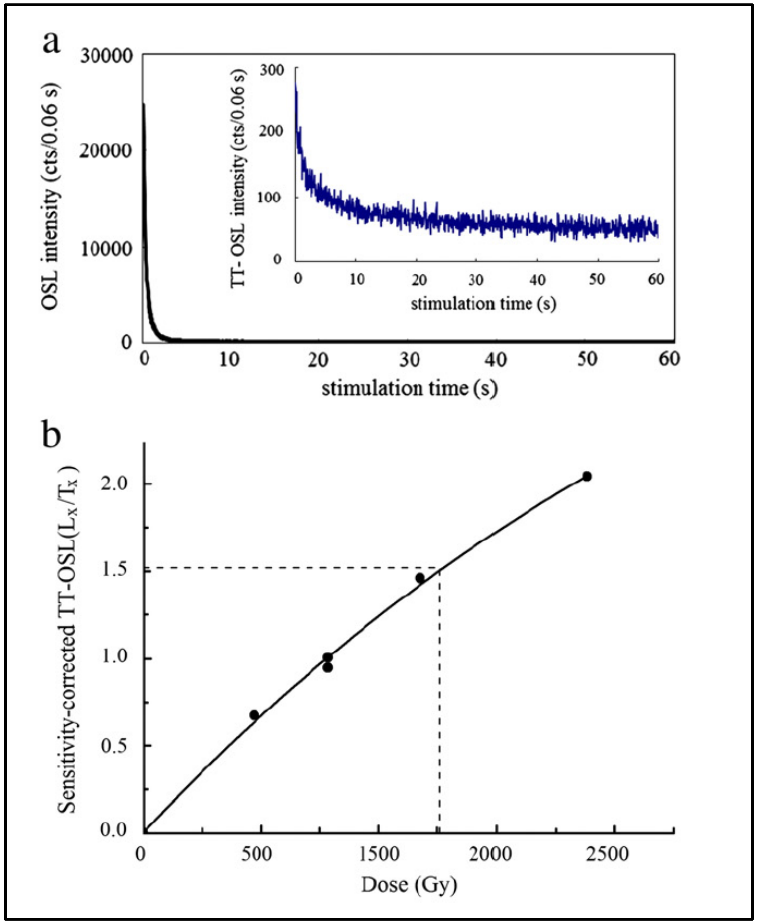


Equivalent Dose Models

Model:	Used for:	Abused for:
Common Age (1 parameter)	Most straightforward; well bleached, not post-depositionally mixed	If positively skewed, gives poor estimate, fits limited samples
Central Age-CAM	Large dispersions where the measured De is not consistent within error of measurements; 15~25% overdispersion parameter	Everything to do with trying to reduce error; can give unrealistic error precision
Minimum Age-MAM (4 and 3 parameters)	Fluvial or alluvial deposits, true values for the equivalent dose are drawn from a truncated normal distribution	Skewing and kurtosis are important to know in detail
Maximum Age	Grains fully bleached at deposition and then mixed with younger intrusive grains; occurs rarely	Limited applications
Finite mixture-FMM	When the sample contains several discrete grain populations (bioturbation and bleached or with additional partial bleach variety)	Generally not to be applied to multi-grain aliquots

Quaternary Geochronology 11 (2012), p. 1-27

Thermal Transfer OSL-Equivalent Dose



Advantages:

1. Access of deep traps using quartz thermal-transfer OSL (TT-OSL) and preliminary assessments by numerous workers are highly encouraging providing preliminary age estimates in the range of 40,000 to 1 million years.
2. Does not require the use of additional machines or equipment.
3. Signals >900 Grays can be measured.

Disadvantages:

1. Each aliquot or single grains requires long bleaching times (300 seconds or more) for each regeneration; thus analysis times are likely to be 12-24 hours per aliquot (grains take 10-15 hours).
2. Sensitivity of the aliquots is increased and therefore the sample should be bright (and fast) for the regular component of OSL.
3. At signals of <50 Gy shows underestimates.

Quaternary Research 79 (2013), p. 168-174. Radiation Measurements 42 (2009), p. 380-391.