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Procedures preparatory to setting up a luminescence pulsing system

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Abstract
Some key tests necessary in the setting up of a luminescence pulsing system are presented. The procedures discussed are concerned with measurement of reliable luminescence-photon counting rates whose analyses provide information about lifetimes and intensity of luminescence measured using pulsed optical stimulation. The paper presents data from a measurement system which used a time-to-amplitude converter for timing.

Introduction
The aim of pulsed optical stimulation is to separate in time the stimulation and emission of luminescence. Pulsed optical stimulation produces a time resolved set of signals displaying the delay between stimulation and emission of luminescence. Time-resolved spectra measured in this way may be analysed for associated lifetimes in order to improve understanding of the dynamics that underlie the emission of the luminescence.

The use of luminescence pulsing techniques has been reported previously including ones based on the use of lasers (Akselrod and McKeever, 1999; Clark et al., 1997; Markey et al., 1995; Sanderson and Clark, 1994) and on light-emitting-diodes (e.g Chithambo and Galloway, 2000). The operation of the systems varied with some laser-based systems using pulsed-lasers (Clark et al., 1997; Sanderson and Clark, 1994) and others mechanical shutters to intercept the laser light and thus provide the stimulation pulse (Markey et al., 1995). In the measurement system of Chithambo and Galloway (2000), the light-emitting-diode pulses were triggered by signals from an integrated circuit multivibrator, a 2N74221. Concerning luminescence detection, the system described by Markey et al. (1995) synchronised the operation of the mechanical shutter with the operation of a gated photon counter whereas the pulsed laser systems of Clark et al. (1997) as well as that of Sanderson and Clark (1994) used a multichannel scaler to record the luminescence-photon counting rate as a function of time.

This paper presents some key tests involved in the setting up of a luminescence pulsing system for routine use. The LED-based pulsing system of Chithambo and Galloway (2000) is used as a case study. This measurement system used a combination of a time-to-pulse-height converter and an analogue-to-digital converter for photon counting and timing of the delay between stimulation and emission of luminescence. The procedures described were performed to ensure measurement of reliable luminescence-photon counting rates whose analyses provide information about luminescence lifetimes and luminescence intensity of the material under study. The preparatory tests discussed may be of interest to others planning to set up or develop a luminescence pulsing system.

Signal detection
Figure 1 shows a schematic diagram of the luminescence measurement assembly. The luminescence photons are detected by a photomultiplier (EMI 9635QA). The signals from the photomultiplier are then amplified and counted in turn by the amplifier (Ortec 474) and constant fraction discriminator (Ortec 473A) respectively. The time-to-pulse height converter (TPHC) (Ortec 467) is used to determine the delay between stimulation and emission of luminescence. This is because in practice the TPHC generates a rectangular output pulse whose amplitude is linearly proportional to the time interval between the arrival of a START and STOP signal to the inputs of the converter. The output pulses from the TPHC are fed into the analogue-to-digital converter (LABEN 8213) which then furnishes the signals, in digital form, to the computer to produce a plot of luminescence-photon counts against time, a time-resolved spectrum. Luminescence time-resolved spectra are displayed with a time range equal to the selected dynamic range on the TPHC.

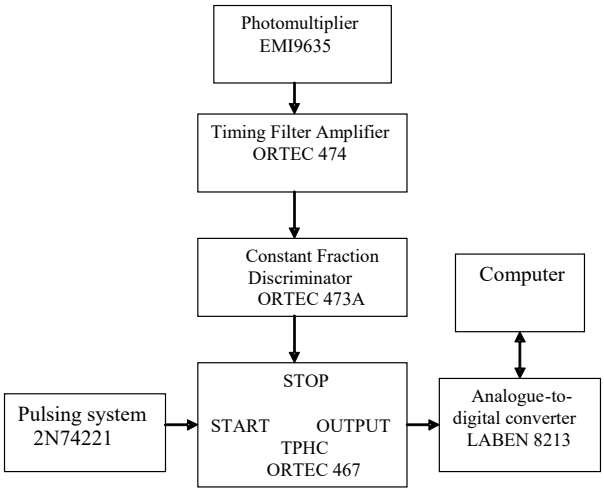

Figure 1: *A block diagram of the luminescence measurement assembly. The time-to-pulse-height converter (TPHC) measures the time interval between stimulation and emission of luminescence .*

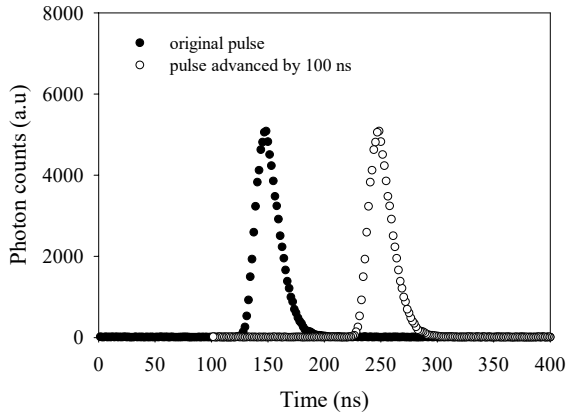

Figure 2: *A light-emitting-diode pulse shifted from its original position by the introduction of a 100 ns delay to the STOP signal.*

Timing

The time-to-pulse amplitude conversion mentioned above can only be performed if a valid START input signal (determined by threshold input voltage) is accepted within the selected time range. The START input is then disabled during this `busy' interval. The acceptance of a valid STOP pulse (again determined by threshold input voltage) indicates that a time interval has been measured and its corresponding analogue signal can then be read at the TPHC output. Thus the acceptance of a START signal is necessary to initiate a response in the TPHC. In the measurement system of Figure 1, the START signal, generated by the 2N74221 multivibrator was fed into the TPHC at a repetition rate of 11 kHz whereas the STOP signals, provided by random luminescence-photons from a quartz sample under stimulation, were obtained from the ORTEC model 473A constant fraction discriminator (Chithambo and Galloway, 2000).

In order to calibrate the time axis and hence determine the resolution of the dynamic range selected, a time-resolved spectrum of a light-emitting-diode (LED) pulse was first obtained with the photomultiplier preceded by only neutral density filters. A delay, Δt, was then introduced to the STOP pulse by connecting a calibrated delay cable between the TPHC and the constant fraction discriminator. When the system was operated again, the LED time-resolved spectrum shifted by a time Δt from its original position. This is shown in Figure 2 for a delay of 100 ns. Since the dynamic range of the time-resolved spectrum was selected on the TPHC beforehand, calculation of the resolution of the time axis was made straightforward.

Measurement of luminescence time-resolved spectra

The luminescence-measurement system of Figure 1 requires that a maximum of one photon be detected for each stimulation light pulse (i.e. for each START pulse). The luminescence-photon signals provide the STOP pulses. The arrival of the first STOP pulse after a START signal will initiate timing in the TPHC. If multiple STOP pulses arrive after a START pulse, the time information recorded will be that of the first STOP pulse. The time information of subsequent pulses will not be recorded and as a result the time-resolved spectrum will be distorted, with later times being falsely low in recorded counts. It is imperative then that for undistorted time-spectra, the STOP pulse rate should be less than the START pulse rate i.e. the luminescence-photon counting rate should be less than the stimulation light pulse rate (for example see figure 3 in Chithambo and Galloway, 2000). Time-resolved spectra with an inherent distortion can lead to apparent but spurious lifetime values.

Assessment of counting rates

In order to establish `safe' levels of counting rates for measurement of time-resolved spectra, the set-up shown in Figure 1 was used to compare the rate of STOP pulses measured simultaneously by a scaler counter and by the TPHC. The number of STOP pulses measured by the TPHC in a given time was determined by integrating the measured time-resolved spectrum over its entire 256 channels. The

rate of STOP pulses was changed over time by simply measuring time-resolved spectra repeatedly from a sample. As the luminescence from the sample decreased in time, so did the rate of STOP pulses. However, the frequency of the START pulse was kept constant at 11 kHz. Figure 3 compares counting rates recorded by the scaler with rates determined from time-resolved spectra for stimulation using green LEDs (Nichia NSPG 500). In the absence of any dead-time in the TPHC, these counts would be equal. However, because there is a finite dead-time in the TPHC, the counts integrated from time-resolved spectra are lower than counts recorded by the scaler. The non-linearity from about 8000 counts s^{-1} (y-axis) occurs because the next and later STOP pulses are being missed by the TPHC. Time-resolved spectra in this region would be extremely distorted as counts would be registered only in the first 2 or 3 channels of the analogue-to-digital converter. Lifetimes calculated from such time-resolved spectra are inevitably spurious. A `safe' working region will therefore be where the count rates integrated from time-resolved spectra are linearly proportional to count rates from the scaler, for instance the region at less than 5000 counts s^{-1} (y-axis).

A further experiment was conducted to see if the performance of the system depends on the rate at which signals are presented to it. This was done by changing the LED current from 10 to 30 mA thereby increasing the light output. Figure 4 shows that, so long as the count rate stays within the "safe" working region, as indicated by the rate of scaler pulses, the performance of the system does not depend on the intensity of the light. This means that time-resolved spectra measured at different light intensities can be compared directly. Beyond the "safe" region, this is not necessarily true as can be seen in Figure 4. The scatter of data points in time-resolved spectra due to variation of intensity is reflected in the errors in lifetimes derived from it (Bailiff, 2000).

The relationship between spurious lifetimes (i.e. 'spurious' according to the criteria discussed above) and counting rates as investigated by Chithambo and Galloway (2000) implies that when measuring a lifetime, the counting rates should be chosen such that the possible spurious lifetime is much longer than the lifetime being measured. It should be noted that even though incidents of spurious lifetimes are more likely in a set up using a TPHC in which 'dead time' effects are inherent, changes in lifetime with counting rates have been reported even for multichannel scalers with multiple-STOP-signal capability (Galloway, 2002). The tests discussed in this paper are therefore necessary in any system intended for measurement of luminescence lifetimes.

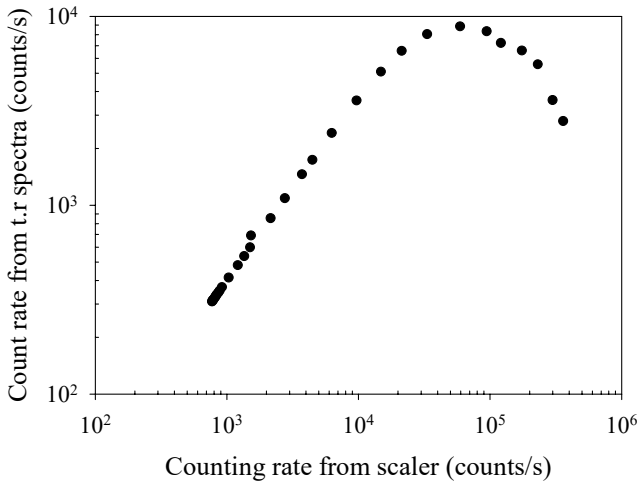

Figure 3: *A comparison of counting rates recorded by a scaler counter with rates determined from time-resolved (t.r.) spectra.*

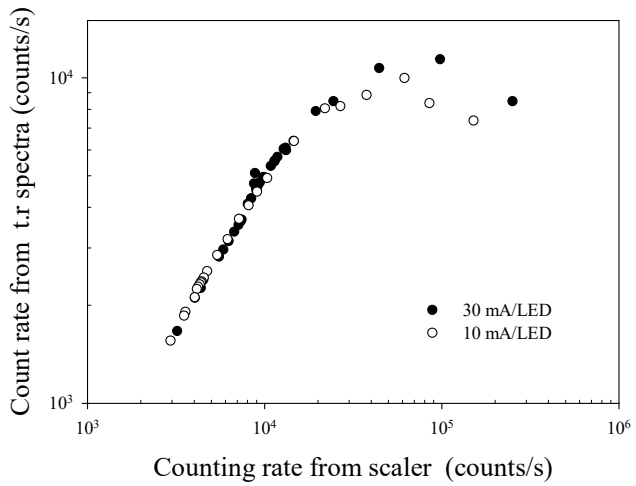

Figure 4: *A comparison of counting rates obtained at 10 and 30 mA per LED.*

Conclusions

Some key tests involved in setting up a luminescence pulsing system for measurement of luminescence lifetimes have been presented. The discussion used an LED-based pulsing system in which a time-to-amplitude converter is used for timing. The preparatory tests discussed may be of interest to others planning to set up or develop systems for measurement of time-resolved spectra.

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Reviewer

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A method for the removal of mica from quartz separates

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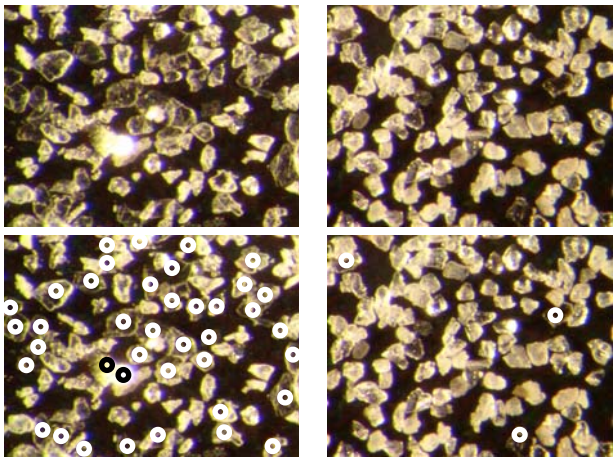
Sediment samples often contain appreciable amounts of mica, a complex group of alumino-silicate minerals with varying chemical composition which have a strong cleavage that results in their platy structure (Klein and Hurlbut, 1993). Muscovite and biotite are usually the most common forms found in detrital sediments. Standard laboratory treatments (Aitken, 1985) to obtain pure quartz or feldspar for luminescence dating do not seem to reject mica minerals. A few studies have described the luminescence properties of mica (e.g. Kristianpoller et al., 1988; Clark and Sanderson, 1994). Not much is known about whether mica is actually a contaminant in luminescence dating studies, in the sense of whether it contributes significantly to the luminescence signals measured from quartz or feldspar. Excess mica can be removed by spreading the sample over statically charged surfaces (e.g. plastic envelopes or beaker surfaces) on which mica particles tend to stick. This, however, has the disadvantage that a considerable amount of quartz is also lost, especially when small grain sizes are used. We describe an effective and simple procedure to remove mica from etched quartz samples using a detergent solution in an ultrasonic bath.

Removal of mica using a detergent

The sediment used for this study was from a sediment core from the southern Baltic Sea (Kortekaas et al., submitted). The samples were wet-sieved to obtain the 63-106 µm diameter fraction. Purified quartz was obtained by treatment with H_2O_2 (10%) to remove any organic material, HCl (10%) to dissolve carbonates, concentrated HF (38%) to etch the surface of the quartz grains and to remove feldspar, and HCl (10%) again to remove any remaining soluble fluorides. However, after these standard laboratory treatments, some of the quartz samples contained up to 60 % mica by volume (by eye; Figure 1a). The low sand content of these samples precluded the use of statically charged surfaces to remove mica, because too large a fraction of the quartz was lost in this process. Instead, the samples were put in a detergent solution (sodium pyrophosphate solution ($Na_4P_2O_7$; 22.3 g/l) or dishwashing detergent solution) in an ultrasonic bath for ~30 minutes. Subsequently, the detergent solution was decanted and the sample rinsed with distilled water. The visible mica contamination, relative to quartz, decreased by ~90 % (see Figure 1) and the measured loss of total mass was 24 %. Presumably, the mica simply floats off when the soap is decanted. To estimate the quantitative quartz loss when applying this procedure, a clean (mica-free) quartz sample (63-106 µm) was processed in the same way, and the loss was <1% of the total starting mass.



(a) (b)

Figure 1: *Photographs of (a) a contaminated sample and (b) the same sample after treatment with detergent in an ultrasonic bath. Mica content decreased by ~90% (by eye). The open circles on the copies of the photographs at the bottom of the figure indicate the mica grains. The sample was taken from the same depth as sample F580, but from the half of the core which had been exposed to light.*

Luminescence measurements

All measurements used a Risø OSL/TL reader with a beta source giving a known dose rate to quartz. Optical stimulation was with blue (470 nm) light emitting diodes (LED), or with infrared (880 nm) LED. Detection was through 7 mm of U-340 glass filter and all stimulation was at 125ºC, the temperature at which routine quartz OSL measurements are performed.

To investigate the possible influence of mica on quartz luminescence measurements, three aliquots of pure mica grains (manually selected under the microscope) were measured using a single aliquot regenerative dose (SAR) protocol with a preheat of 220ºC and a cut heat of 160ºC (as was used with the quartz samples). The mica consisted mainly of muscovite and some biotite. The blue light stimulated natural signals from these 3 mm diameter aliquots of mica (63-106 µm) were detectable from two of the three aliquots, and was low (respectively 18, 84 and 698 photons in the first 0.8 s) (Figure 2a). Clark and Sanderson (1994) have shown that mica gives a luminescence signal under infrared (IR) stimulation, but we did not detect any IR stimulated luminescence following a beta dose of ~30 Gy (Figure 2b). However, a measurable sensitivity to blue light was observed. The blue light OSL decay curves after a beta dose of ~60 Gy (approximately double the quartz D_e of the sample) are shown in Figure 2c for all three aliquots. The natural signal from purified quartz of similar burial dose to the mica sample F580 is shown in Figure 2d. Note that both aliquot 3 and sample F560 were measured on a different reader from aliquot 1 and 2, but nevertheless it appears that the mica signal is small compared to the quartz signal. Although it is not possible to directly compare the relative brightness of the signals, it should be noted that the rate of optical eviction from the mica samples (Figure 2c) and the quartz sample (Figure 2d) is similar.

It is possible that the blue light stimulated OSL signal from sedimentary mica is from fine quartz grains that adhered to the mica grains. The samples were treated with concentrated HF, so fine grain quartz contamination seems unlikely, but it is possible during manual mounting of mica grains that quartz grains were inadvertently included. In order to check this, we measured OSL and TL on museum specimens of mica (muscovite) and compared them with the signal from sedimentary mica and purified quartz. The museum specimens of muscovite were crushed to approximately 2 mm diameter, and rinsed with distilled water in a 150 µm sieve to remove possible dust particles. The low temperature TL glow curve of our museum sample (after heating to 350°C

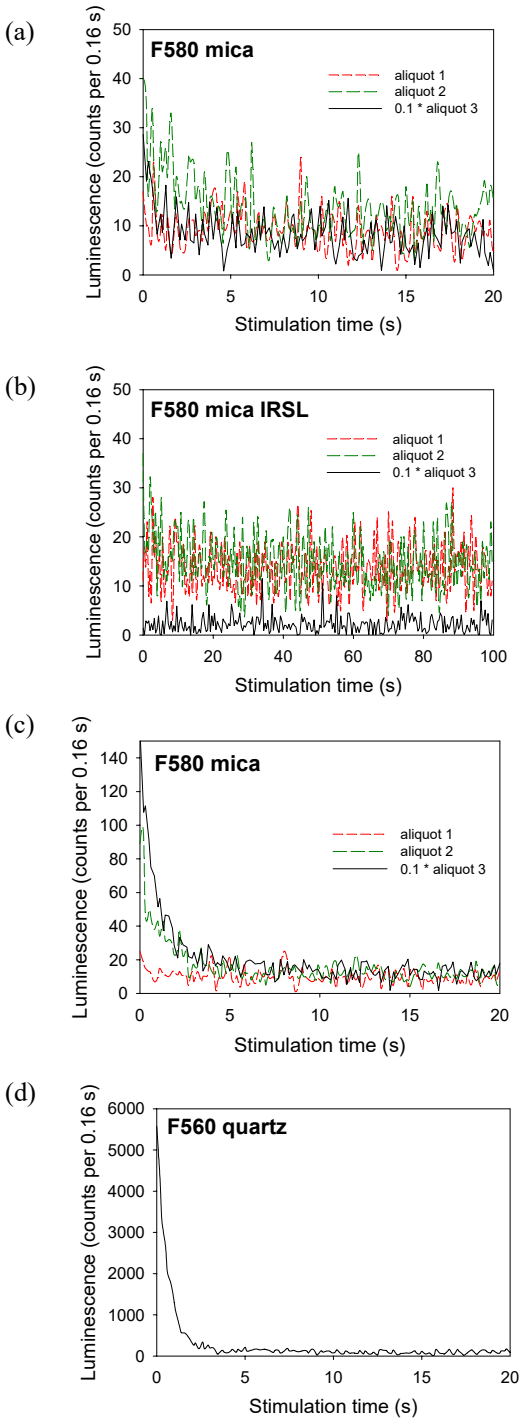


Figure 2: *(a) OSL decay curves for three 3 mm aliquots mica (63-106 µm) show a very weak natural sensitivity to blue light (aliquot 2 and 3) and (b) no visible sensitivity to IR. (c) The OSL decay curves after the same aliquots have been given a 60 Gy dose. (d) A typical OSL decay curve for a purified quartz sample of similar depth and burial dose (D_e ~30 Gy). Note that in (a), (b) and (c), the results for aliquot 3 have been multiplied by 0.1 for display purposes.*

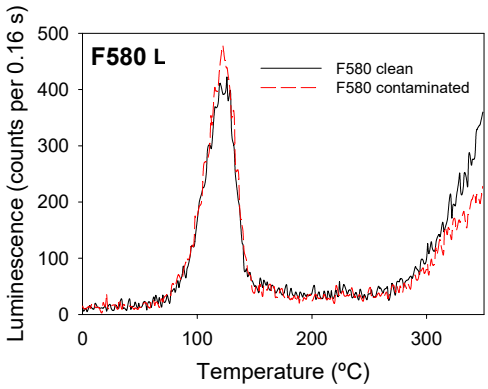


Figure 3: *TL glow curves for both a mica contaminated sample and the same sample, after removal of mica using the method described in this paper, after a ~50 Gy dose (light exposed F580). Heating rate was 5ºC/s.*

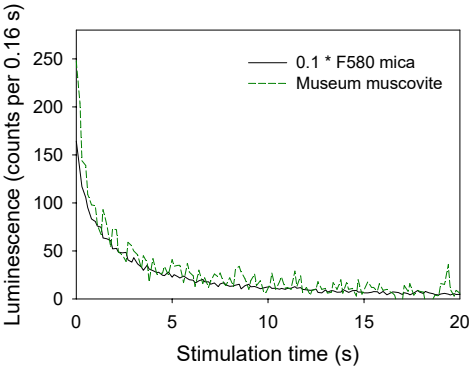


Figure 4: *OSL decay curves for an aliquot of sedimentary mica F580 (solid line) and an aliquot with museum specimens of muscovite (dashed line) after a 700 Gy dose. The dark count of the reader system was subtracted from these data sets to enable comparison of the curve shapes.*

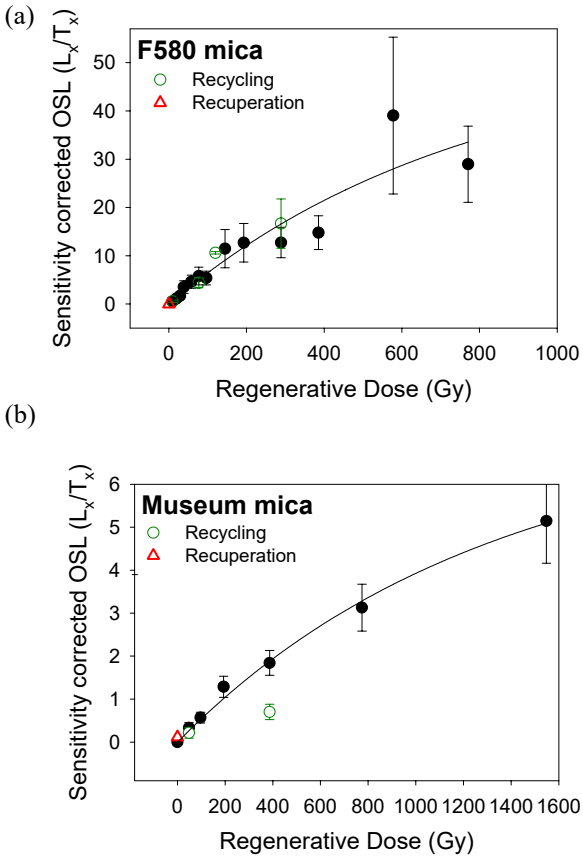


Figure 5: *Single aliquot regenerative dose growth curves using a 220ºC preheat for 10 s and a 160ºC cut heat for (a) sedimentary mica (F580) and (b) the museum specimen of muscovite.*

and giving a dose of 200 Gy) showed a peak just above 100ºC which was visually indistinguishable from the 110ºC TL peak from a purified quartz sample, although several orders of magnitude less sensitive. Thus the presence/absence of a similar weak TL peak in the sedimentary mica aliquots cannot be taken as evidence for quartz contamination. Figure 3 shows the TL glow curves from both a mica contaminated quartz sample and the same sample after removal of the mica (light exposed F580) after a ~50 Gy dose. No significant differences can be seen in the shape of the TL glow curve after removal of the mica. The OSL decay curves were also indistinguishable although the contaminated sample had a lower absolute light level. Figure 4 shows the blue stimulated OSL decay curves from aliquots of both museum muscovite and sedimentary mica (F580) after a 700 Gy dose; the high dose was used to make the shape of the decay curve clearer. The OSL decay curve of the museum muscovite specimen shows an initial fast decaying component, similar to that of quartz, but the signal also contains a significant slow component. The OSL decay from the sedimentary mica is similar. As a further check we have measured the growth curve of both the sedimentary mica (F580) and museum muscovite (Figure 5a and b). Although the sedimentary mica (Figure 5a) shows significant scatter, saturation seems to be at much higher doses than for quartz. The museum muscovite is still not in saturation at 1600 Gy.

We conclude that we cannot be completely sure that these mica luminescence signals are not, in fact, derived from quartz contamination, but given the similarity to the response of the museum sample, this seems unlikely. In any case, it seems prudent to minimise mica content when this forms a large part of a quartz sample after etching, especially in older samples. The method that we have proposed for

removing mica, using a detergent solution, is effective and is less likely to involve inadvertent loss of quartz. In this study, most of the sedimentary mica consisted of muscovite and some biotite. These were not separated, and we do not know whether different mica minerals possess different luminescence characteristics. Further investigations are necessary to determine whether these observations are generally applicable and whether mica itself has any potential as a luminescence dosimeter.

Acknowledgements
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Reviewer
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Thesis Abstracts

Author: ZhongPing Lai
Thesis Title: Luminescence dating of Chinese loess
Grade: DPhil
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The thesis has two parts: the application of quartz OSL dating to solve problems in loess research and the study of red luminescence emissions from both quartz and feldspar in order to seek the possibility of extending the luminescence dating range of Chinese loess.

In the first part of the thesis, a new approach has been proposed to locate and date the boundary between the Holocene and the Pleistocene (H/P) in Chinese loess. It assumes that the loess sedimentation rate is lower during the Holocene than during the Last Glaciation, and that the inflexional point of the sedimentation rate change is the location of the H/P boundary. The sedimentation rate can be calculated using high-resolution luminescence (quartz OSL) chronology. The age of the H/P boundary in Chinese loess was determined for the first time using this approach. The continuance of loess deposition, an assumption behind the correlation between the palaeoclimatic records in loess and that in ocean sediments or ice cores which has been challenged recently, has been examined for L1 loess by establishing high-resolution quartz OSL chronology. It has been demonstrated that loess deposition during the Last Glaciation has been continuous in the section studied. The location and age of the boundary between Marine Isotope Stage (MIS) 2 and 3 has also been defined for the first time for Chinese loess using the above-mentioned approach. The mass accumulation rates have been calculated for MIS 1, 2 and 3 for the studied loess sections. The possibility of a standardised growth curve (SGC) when using the single aliquot regenerative-dose (SAR) protocol in OSL of loess quartz has been explored. The results show that a SGC exists, and that this SGC offers an alternative approach for De determination up to about 200 Gy for loess samples from the Chinese Loess Plateau.

The second part of the thesis is the study of red emissions from both quartz and feldspar with the purpose of exploring the potential of these signals for extending the luminescence dating range for loess. The study has shown that: a) red TL of quartz and red IRSL of feldspar can be detected from Chinese loess; b) using red TL of quartz, the De determined by a modified SAR protocol is overestimated, and the red TL residual level is more than 100 Gy; c) the detection of red IRSL of feldspar from Chinese loess has been successful after a modification to the Risø Reader, and some physical characteristics of red IRSL have been observed.

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Thesis Title: Development of optically stimulated luminescence dating techniques for application to terrestrial and martian studies
Grade: PhD
Date: December 2005
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Geological processes including aeolian and fluvial activity have shaped the surface of Mars. The temporal timescale on which these events have taken place is important for understanding the geological history of Mars, including time periods in which life may have developed on the planet. However, methods do not currently exist that can be used in-situ on Mars to constrain the recent (younger than 1 million years) geological timescale. It has been suggested that optically stimulated luminescence (OSL) dating, which measures the radiation dose and dose rate minerals are exposed to over time and hence the burial time, can be developed as an in-situ tool for delineating the timing of these recent events. This study attempts to develop some of the necessary techniques for measuring the radiation dose in martian minerals by studying martian soil simulants and meteorites.

Most of the luminescent materials that will be encountered on Mars are different from those typically used for OSL dating on Earth. However, the techniques used for absorbed radiation dose determination in terrestrial OSL dating studies can be adapted to martian simulants and meteorites with a few minor but important changes. These changes have to do with the heat treatment of the samples prior to OSL readout as well as the temperature of irradiation and OSL measurement due to the ambient temperature of Mars. While many scientific challenges must still be overcome for this project, this study provides a basis for further study of martian simulants.

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Conference Announcements

4th New World Luminescence Dating Workshop

31st May – 1st June 2006

The United States Geological Survey (USGS) is pleased to sponsor the Fourth New World Luminescence Dating Workshop (NWLDW) to be held in Denver, Colorado. This workshop will follow the "tradition" set in Tulsa, OK; Albuquerque, NM and Halifax, Nova Scotia. Workshop presentations are planned for May 31 to June 1, 2006 (Wednesday and Thursday) at the Denver Federal Center (Building 25). We anticipate two days of presentations and some time for tours of the ice-core lab, water quality lab or the TRIGA reactor. All presentations will be oral.

This meeting will be of interest to luminescence dating specialists, Quaternary geologists, archaeologists, dosimetric scientists and some physics researchers. Interested people should consult the following URL for information and deadlines. http://crustal.cr.usgs.gov/laboratories/luminescence_dating/index.html

Information regarding the workshop will be updated monthly or as required. We anticipate the call for abstracts will have a February 24, 2006 deadline. At this time we do not know the cost for the workshop, but we are making every effort to have an affordable session so as many students may participate as possible. The mailing list will be drawn from the Reno 2002 and Cologne 2005 LED conferences, but additional requests can be added by contacting smahan@usgs.gov

We include the following URL's for information on near-by hotels to the area as well as maps to the Denver Federal Center. The closest motels to the DFC are Candlewood Suites, Comfort Suites and Days Inn-Denver West. Denver is not a public-transit friendly city, so you should anticipate renting a car or have someone in your group rent a car, as you will have very limited options for transportation once you arrive. If, however, you need to stop for directions, be assured that most of the people are more friendly and helpful. A group dinner on Wednesday at the Mount Vernon Country Club in Golden, Colorado is also offered. If enough interest is received, a trip to the world-famous Florissant National Monument fossil site will be planned for the day after the workshop.

http://ocrs.cr.usgs.gov/map/dfcmap.html
http://ocrs.cr.usgs.gov/map/dfcdiamap.html
http://www.nps.gov/flfo/index.htm
http://www.goldencochamber.org/Category.asp?Cat_id=1811

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Conference Announcements

UISPP' XV World Congress

Lisbon 4th to 9th September 2006

The International Union for Prehistoric and Protohistoric Sciences (UISPP/IUPPS), would like to invite you to assist the next major activity, the XV World Congress, held in Lisbon, in Portugal, in September 2006.

The Congress will consist of Colloquia, workshops and Sections (To see the list of the different topics at http://www.uispp.ipt.pt/en/enmain.html) and is open to everyone who wishes to assist or contribute with a presentation from the fields of earth sciences, archaeology and related areas.

The Congress will take place at the University of Lisbon (Alameda da Universidade) in September 2006, under the organization of a National Secretary hosted by the Polytechnic Institute of Tomar. To obtain more information and register please visit the webpage which can be viewed at the following web page http://www.uispp.ipt.pt/.

One of the Colloquia already presented is related with the Luminescence Dating (C69), and is called:

Luminescence Dating Techniques: a User's Perspective

Dating beyond the range of radiocarbon (c. 40 000 years ago) continues to be a challenge; a source of considerable frustration to archaeologists and others interested in the important events of the period c. 200,000 to 40,000 years ago. In the absence of volcanic sediments, the most successful techniques applicable to this time range are luminescence techniques: principally thermoluminescence, optically and infrared stimulated luminescence, also electron spin resonance. These methods depend on the conditions surrounding the sample during burial, and pose a number of challenges. Many archaeologists who use luminescence and ESR dates have a very limited understanding of how the techniques work, and how to use them optimally. This workshop is intended to bring together dating specialists and archaeologists and other "consumers" of dates, and to promote a critical and informed approach to the use of the techniques. The emphasis will be on understanding the limitations of the techniques, factors likely to affect the dates obtained, and how best to go about designing dating strategies for sites.

Conference Announcements

UK Luminescence and ESR Meeting

Department of Geography
University of Liverpool

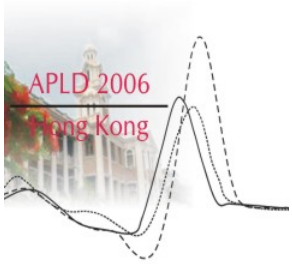
10-13th September 2006

THE UNIVERSITY of LIVERPOOL

The annual UK luminescence and ESR dating research meeting will be held at the University of Liverpool from the 10-13th September 2006. The meeting is intended to provide a forum for the presentation and discussion of the latest research in trapped charge dating and related work. Presentations covering basic physics, methodological issues and the application of these techniques are all welcome. The meeting will consist of both oral and poster presentations, and presentations by research students are especially encouraged.

For further information send an e-mail to: Lum2006@liverpool.ac.uk

Conference Announcements



The 1st Asia-Pacific Conference on Luminescence Dating

APLD2006

23-26 October 2006, HONG KONG

The conference, although aimed primarily at Asia-Pacific countries, is open to participants from all over the world. APLD 2006 will bring together different experts who are interested in luminescence dating. The topics will range from fundamental studies, through advances in equipment technology and analytical procedures, to applications on geological and archaeological materials. APLD2006 will also welcome papers on electron spin resonance dating and luminescence dosimetry studies.

A few invited lectures will provide an overview of the main topics. Both oral and poster presentations will be considered.

General information

Persons interested in attending the conference are kindly asked to fill in and return a copy of the application-form as an Email attachment to apld2006@hku.hk or by FAX to ++852 2517 6912. Early returns are essential for proper planning of logistical matters. A second Email announcement will be sent in the beginning of 2006. We recommend the conference WEB-page for regular up-dates and links at http://web.hku.hk/~APLD2006.

Proceedings

Proceedings of both oral and poster presentations may be eligible for peer-reviewed publications in the journals Geochronometria and Quaternary Geochronology. The official language of the conference and of the proceedings is English.

Conference Secretary

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