UK Luminescence and ESR Meeting 2012

Programme and Abstracts

Geoff Duller
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Institute of Geography and Earth Sciences
Aberystwyth University

12-14th September 2012

Conference Programme

Tuesday 11th September 2012

17.00 – 20.00 Reception drinks and registration in Arts Centre theatre bar

Wednesday 12th September 2012

09.15 – 09.30 Introduction

Equipment Chair: Grzegorz Adamiec

09.30 – 09.50 T. Lapp, M.H. Kook and J-P. Buylaert
Dead time correction and sample camera for the Risø TL/OSL reader

09.50 – 10.10 K. Dornich, M. Krbetschek, A. Richter and D. Richter
A new measurement system for luminescence dating – LEXSYG

10.10 – 10.30 M.H. Kook, T. Lapp, A.S. Murray and C. Thiel
A Risø XRF attachment for major element analysis of aliquots of quartz and feldspar separates

10.30 – 11.00 *Coffee*

Extending the Age Range Chair: Kristina Thomsen

11.00 – 11.20 C. Ankjaergaard, M. Jain and J. Wallinga
Extending the quartz age range using violet stimulation

11.20 – 11.40 G.A.T. Duller
Application of single grain quartz OSL and TT-OSL to sediments at Kalambo Falls: How far can we go?

11.40 – 12.00 J.F. Liu, J. Chen, A.S. Murray, M. Jain, J.P. Buylaert and Y.C. Lu
Testing TT-OSL and Post-IR IRSL methods on old (<780 ka) lacustrine deposits from Nihewan Basin (northern China)

12.00 – 12.20 M. S. Chapot, G.A.T. Duller and H.M Roberts
Does pulsed irradiation hold the key to using TT-OSL to date old samples?

12.20 – 13.30 *Lunch*

New materials and new methods Chair: Ann Wintle

13.30 – 13.50 E. Philip, N. Porat, A. Agnon and Z. Reches
Thermo- and optical luminescence of fault gouge: experimental results

13.50 – 14.10	B. Guralnik, F. Herman, M. Jain, R.B. Paris, P.G. Valla, A.S. Murray and E.J. Rhodes **The theory of trapped charge thermochronometry**
14.10 – 14.30	P. Valla, B. Guralnik, S.E. Lowick, J-D. Champagnac, F. Herman, M. Jain and A.S. Murray **Quantifying glacial erosion and relief evolution using luminescence thermochronometry (Granite Range, Alaska)**
14.30 – 14.50	R.J. Stirling, G.A.T. Duller and R. Nathan **Progress towards absolute dating of calcium carbonate snail opercula: a potential chronometer spanning 3 million years**
14.50 – 15.10	R. Sohbati, A.S. Murray, M. Jain and M.S. Chapot **Optically stimulated luminescence (OSL) as a chronometer for surface-exposure dating**
15.10 – 15.40	*Tea*
	New materials and new methods Chair: Manfred Frechen
15.40 – 16.00	T. Reimann, C. Ankjaergaard, M. Jain, S. Tsukamoto and J. Wallinga **Testing the potential of 'Natural sensitivity correction' methods**
16.00 – 16.20	S. Tsukamoto, K.S. Kataoka, T. Oguchi and G. Komatsu **Luminescence dating of scoria fall and lahar deposits from Somma-Vesuvius, Italy**
16.20 – 16.40	D.C.W. Sanderson, T.C. Kinnaird, S. Murphy, M. Ghilardi and A. Bickett **Post Stimulation Phosphorescence (PSP) as a luminescence profiling indicator: application to the Villeneuve-lez Avignon sediment cores**
16.40 – 18.00	**Poster Session** Chair: Geoff Duller

Thursday 13th September 2012

Statistical methods and assessing uncertainty Chair: Richard Bailey

09.00 – 09.20 L. Clark-Balzan and S. Burrough
A Bayesian framework for luminescence ages

09.20 – 09.40 J. Wallinga, A.C. Cunningham, J. Den Ouden, P. Copini, A.J. Versendaal, U.G.W. Sass-Klaassen, G. Bos, A.M.A.J. Beerens and M.J.P.M. Riksen
Dating a lot of sand and one tree: testing the bootstrap likelihood Bayesian OSL approach with dendrochronological age constraints

09.40 – 10.00 G. Adamiec, A. Bluszcz and A.J. Heer
Statistics of counts from a photomultiplier tube and D_e error estimation in the SAR protocol

10.00 – 10.20 A.S. Murray, J.P. Buylaert and C. Thiel
Results from a laboratory intercomparison based on a beach-ridge sand from Skagen (Denmark)

10.20 – 11.00 *Coffee*

Statistical methods and assessing uncertainty Chair: Jakob Wallinga

11.00 – 11.20 K. Thomsen and A.S. Murray
Testing single-grain OSL methods using known age samples

11.20 – 11.40 R.M. Bailey
An attempt to understand scatter in D_e

Dosimetry Chair: Jakob Wallinga

11.40 – 12.00 G. Guérin, M. Jain, K.J. Thomsen, A.S. Murray and N. Mercier
Modeling the overdispersion in single-grain dose populations arising from heterogeneous potassium distribution in sedimentary media

12.00 – 12.20 S. Kreutzer, C. Schmidt, R. DeWitt and M. Fuchs
The a-value of polymineral fine grain samples measured with the post-IR IRSL protocol

12.20 – 14.00 *Lunch (including posters)*

Developments in dating using feldspars Chair: Christina Ankjaergaard

14.00 – 14.20 X. Fu and S.H. Li
A modified multi-step post-IR IRSL protocol for dating of Holocene sediments using K-feldspar

14.20 – 14.40 R.K. Smedley and G.A.T. Duller
Grain-to-grain variability in residuals of the post-IR IRSL signal in K-feldspars

14.40 – 15.00 J.P Buylaert, A.S. Murray, A.C. Gebhardt, R. Sobhati, C. Ohlendorf, C. Thiel and B. Zolitschka
Post-IR IRSL dating of a 100m long lake core from Laguna Potrok Aike maar lake (Argentina): insights into bleaching history

15.00 – 15.20 G.E. King, H.M. Roberts and G.A.T. Duller
Dating polymineral fine grain loess deposits using the post-IR $IRSL_{290}$ protocol: A cautionary tale

15.20 – 16.00 *Coffee*

Developments in dating using feldspars Chair: Ian Bailiff

16.00 – 16.20 C. Thiel, K.J. Thomsen, A.S. Murray, S. Flude and M. Storey
Towards a better understanding of natural K-feldspar equivalent dose distributions

16.20 – 16.40 H.M. Roberts
Extending the numerical chronology of lacustrine records using luminescence dating

16.40 – 17.00 M. Trauerstein, S.E. Lowick, F. Preusser and F. Schlunegger
An attempt to date potassium-rich feldspar that suffers from partial bleaching and high fading rates

17.30 Depart from Arts Centre for National Library

17.50 Drinks Reception and tour of the National Library of Wales

20.00 for 20.15 Conference Dinner at Medrus, Penbryn

Friday 14th September 2012

Alpine studies Chair: Georgina King

09.00 – 09.20	A. Heer, G. Adamiec and P. Moska **Exploring luminescence measurement level approaching best the expected D_e in complex postglacial sediments of Wauwilermoos, Swiss Plateau**
09.20 – 09.40	D. Gaar, S.E. Lowick and F. Preusser **Comparing single grain and small aliquot quartz OSL and feldspar IRSL dating applied to Alpine glaciofluvial sediments from the Swiss Midlands**
09.40 – 10.00	S.E. Lowick and F. Preusser **Independent dating methods versus pollen chronology – establishing reliability**
10.00 – 10.20	L. Bickel, J. Lomax, C. Lüthgens and M. Fiebig **Exploring the luminescence properties of quartz and feldspar of glaciofluvial outwash terraces in the northern Alpine Foreland (Upper Austria)**
10.20 – 11.00	*Tea*

Applications of luminescence dating Chair: Phil Toms

11.00 – 11.20	N. Porat, U. Avner, A. Holzer, R. Shemtov and L.K. Horowitz **Third millennium B.C. carnivore traps from the Negev Desert (Israel)**
11.20 – 11.40	R.A.J. Robinson, G.E. King, R. Sommerville and W.E.N. Austin **Optically stimulated luminescence dating of Late Holocene marine sediments from Loch Sunart, Scotland, UK**
11.40 – 12.00	D. Sechi, M.D. Bateman, S. Andreucci and V. Pascucci **A comparison of post IR-$IRSL_{290}$ and post IR-OSL derived dates from coastal deposits on NW Sardinia (Italy)**
12.00 – 12.20	W.K. Thompson, G. Guérin, J.P. Buylaert, A.S. Murray and R. Pope **A chronological framework for Late Quaternary landscape evolution related to regional climatic change on Mallorca (Balearic islands, Spain) using optically stimulated luminescence**
12.20 – 12.30	*Closing Comments*
12.30 – 13.30	*Lunch*

End of Conference

Posters

1. R.M. Bailey and S.L. Burrough
   Stripping out the geomorphological evidence: luminescence signals as more than a dating technique?

2. A.C. Cunningham and J. Wallinga
   Bootstrap likelihoods of the Minimum Age used to incorporate fluvial samples into a Bayesian chronological model

3. S. Eccleshall, A. Hormes and F. Preusser
   Sedimentary logging and luminescence dating of the Kapp Ekholm Site, Svalbard

4. M. Evans
   Optically stimulated luminescence dating of the Heelbo alluvial slope deposit, Free State Province, South Africa

5. G. Faershtein, N. Porat, Y. Avni and A. Matmon
   OSL dating of Late Pleistocene aggradation-incision transition in the Negev Highlands, Israel

6. A.A. Finch
   Time-Resolved Luminescence Spectroscopy on the St Andrews Luminescence System

7. M.C. Fuchs, S. Kreutzer, C. Schmidt, M. Dietze, M. Fischer and M. Fuchs
   Introducing an R package for luminescence dating analysis

8. Y. Ganzawa, S. Shimizu and Y. Kanbara
   Preliminary OSL dating of an active fault movement from 1858 using several quartz grain sizes

9. A.F. Halfen and W.C. Johnson
   Does higher resolution OSL sampling lead to better chronological interpretation of aeolian dunefields?

10. J.D. Hassall and S.J. Armitage
    The age, genesis and significance of the sterile dune sand at Blombos Cave, South Africa

11. K. Ito, G.A.T. Duller, H.M. Roberts, N. Hasebe, S. Arai, T. Nakamura and K. Kashiwaya
    The post IR IRSL characteristics of polymineral fine grained sediments from Darhad Basin and Lake Hovsgol, Mongolia

12. M.J. Jestico, T. Stevens, G. Evans and A. Kirkham
    Constraining Late-Quaternary sea-level change in the Arabian/Persian Gulf using optically stimulated luminescence

13. W.C. Johnson, P.R. Hanson, A.F. Halfen and E.P. Gaines
    Success in dating late-Pleistocene dunes in central Alaska using a Post-IR IRSL protocol

14. T.C. Kinnaird, D.C.W. Sanderson, M. Ghilardi, A. Bicket, M-A. Vella, O. Diouf and co-workers at CEREGE
    Sous le Pont d'Avignon: OSL dating of sediments in the lower Rhone at Villeneuve les Avignon

15. C.L. Leighton and R.M. Bailey
Investigating the potential of HCl-only treated samples for range-finder OSL dating

16. J. Lomax
Post IR IR and TT-OSL dating of South Australian palaeodunes – How far back can we push the time scale?

17. G.I. López and N. Porat
Over-dispersion: a potential sedimentological proxy for underwater sediments?

18. V. Lukich and S.J. Armitage
Single-grain OSL dating of the Middle Palaeolithic site Lusakert, Armenia

19. A. Medialdea, K.J. Thomsen, A.S. Murray and G. Benito
Comparison of the performance of age-models in the OSL dating of historical and modern-age flash-flood sediments

20. N. Mercier
Bleaching residuals of IR_{225}/post-IR signals in fluvial sediments

21. Á. Novothny, G.Y. Gábris, S. Tsukamoto and M. Frechen
Testing post-IR OSL, pulsed OSL and post-IR IRSL protocols for fluvial samples from Tiszasas (Hungary)

22. R.N. Palamakumbura, T.C. Kinnaird, A.H.F. Robertson and D.C.W. Sanderson
Late Pleistocene to recent uplift of coastal terraces in Northern Cyprus constrained by OSL

23. N.J Russell and S.J. Armitage
A comparison of single-grain and small aliquot dating of fine sand from Cyrenaica, northern Libya

24. C. Schmidt, S. Kreutzer and A. Hilgers
Thermal stability of OSL components of silex (amorphous/microcrystalline SiO_2)

25. G.Y. Sipos, T. Kiss, B. Sümeghy, P. Urdea, O. Tóth, O. Katona and A. Onaca
Late Pleistocene-Holocene development of the Maros alluvial fan, Hungary-Romania, revealed by luminescence dating

26. T. Stevens, S.B. Marković and M. Zech
Quartz OSL and polymineral post-IR IRSL dating of the Irig loess profile in Vojvodina, Serbia

27. C. Thiel, M.H. Kook, A.S. Murray and T. Lapp
Luminescence and chemical composition – two case studies using the new Risø XRF attachment

28. S. Tsukamoto
Performance of pulsed OSL stimulation for minimizing feldspar OSL signal from quartz samples

29. A. Zink and E. Porto
Dosimetry investigation using NaI(Tl) gamma-ray spectrometer in various environments

Statistics of counts from a photomultiplier tube and D_e error estimation in the SAR protocol

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In the current work we explore a realistic estimation of statistical uncertainties of D_es estimated using SAR OSL measurements. Earlier work by Adamiec et al. (2012) showed that the numbers of counts do not obey the Poisson statistics and, in addition, background counts and light induced counts differ in their deviation from Poisson distribution. Here we show in-depth considerations of these results. We conclude what is the statistical distribution of the numbers of counts and from there we proceed to realistic numerical generation of pseudo-random numbers of counts obtained in OSL measurements. This in turn is used to test possible statistical treatment of OSL data and suggest the optimal statistical treatment of OSL SAR measurement results to obtain unbiased D_e estimates and their uncertainties.

References:
Adamiec G., Heer A. and Bluszcz A., 2012. Statistics of count numbers from a photomultiplier tube and its implications for error estimation. Radiation Measurements, DOI: 10.1016/j.radmeas.2011.12.009

Extending the quartz age range using violet stimulation

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Optical stimulated luminescence (OSL) dating of quartz is widely used in geological and archaeological research to determine the time of deposition of sediments. Unfortunately, the quartz fast component blue light stimulated luminescence signal saturates at relatively low doses, usually limiting the applicability of quartz OSL dating to the last 150,000 years.

One approach to extending the age range was suggested by Jain (2009). He used violet (405 nm) light to directly probe deep traps in quartz; each violet stimulation was preceded by blue light bleaching of the early saturating fast OSL component. This work showed promising results with dose responses of up to >1.5 kGy and an acceptable dose recovery of 300 Gy.

In this study, we further investigate the applicability of the Violet Stimulated Luminescence (VSL) signal for dating Quaternary deposits. We will present an updated protocol for measuring the VSL signal which overcomes the previously encountered large sensitivity changes. To investigate the potential of the VSL signal for dating, we determined dose response curves, bleaching properties, remnant doses in modern samples, and thermal and a-thermal stabilities. We also performed dose recovery experiments of doses up to > 1 kGy.

To test the applicability of the VSL signal on geological samples, we are investigating multiple samples from a core in the south-central Netherlands which penetrates a 35-m thick sequence of Middle to Late Pleistocene deposits of aeolian and fluvial nature (Boxtel core, Schokker et al., 2005). The samples were previously dated using quartz OSL (Schokker et al., 2005) and feldspar infrared stimulated luminescence dating (Wallinga et al., 2007; Kars et al., 2012). Because dose rates are very low, a reliable quartz OSL chronology is available up to ~300 ka; providing an excellent opportunity to test VSL dating for this younger range.

References:
Jain, M., 2009. Radiation Measurements 44, 445-452.
Kars, R.H., et al., 2012. Quaternary Geochronology, in press.
Schokker, J. et al., 2005. Quaternary Science Reviews 24, 2243–2264.
Wallinga, J. et al., 2007. Quaternary Geochronology 2, 216-221.

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An attempt to understand scatter in D_e

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One of the common problems faced when applying optical dating to sediments is that of deciding how to estimate the burial dose when D_e estimates are significantly over-dispersed/scattered. Known sources of scatter include heterogeneous bleaching, heterogeneous radiation fields during burial, post-depositional mixing (e.g. bioturbation) and intrinsic differences in the response of individual grains to the chosen D_e measurement procedure. Distinguishing between these sources of scatter is not straightforward but is sometimes necessary if accurate estimates of the burial dose are to be obtained. This presentation is about an attempt to understand quantitatively (using both simulation and empirical data) how different grain histories/properties control D_e and how the information derived from D_e and OSL data might be used to infer parameters such as the burial dose.

Stripping out the geomorphological evidence: luminescence signals as more than a dating technique?

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Over the last decade, luminescence dating has become established as a routinely used geochronological tool in geomorphology. More recently, analysis of the multi-component OSL signal, using for example D_e(t) data (where the equivalent dose (D_e) calculated using successive intervals of the decaying OSL signal), has been frequently used to resolve the relative size of individual signal components. Such analysis has significant relevance to geomorphology since it provides some information on the characteristics of the bleaching event being dated and thus potentially the nature of the geomorphological processes associated with sediment deposition. In this new application of luminescence data, D_e(t) data have been used both to infer subaqueous versus aeolian deposition and to assess the significance of partial bleaching of fluvial and lacustrine sediments. The interpretation of D_e(t) data in quartz optical dating studies is not however currently straightforward. The dependence of D_e on t is due to the relative D_e of the constituent signal components and in the simplest case where all components record the same D_e, D_e(t) is constant. The balance of component D_e values is affected by the completeness of signal re-setting prior to deposition and also potentially by differences in component signal stability/dose-saturation, and procedural artefacts which may disproportionately affect specific components (e.g. background subtraction, inadequate dose sensitivity correction). Our central aim was to develop a model which was capable of predicting D_e(t) data under a range of circumstances, and to use this to assess under what scenarios examination of D_e (t) data is expected to be useful as a geomorphological tool.

We have explored the behaviour of D_e(t) form using a numerical model which incorporates component-specific bleaching from a mean daylight spectrum, the effect of underwater spectral attenuation, variations in component composition and thermal stability, and specified sample histories. Model predictions are evaluated against laboratory-based experiments with blue-light and natural daylight bleaching, combined with a range of pre- and post-bleaching radiation doses. We have found that signatures of incomplete bleaching (an increase of D_e with t) are identifiable following both blue and daylight (partial) bleaching, and we discuss both the accuracy of the model and implications for the practical use of the D_e(t) method for samples with various irradiation histories, component compositions, component stabilities and depositional settings.

Exploring the luminescence properties of quartz and feldspar of glaciofluvial outwash terraces in the northern Alpine Foreland (Upper Austria)

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The Northern Alpine Foreland (NAF) has been a playground for Quaternary scientists since more than 150 years. The timing of the alpine glaciations – in particular beyond the dating limits of ^{14}C dating – was constructed mostly based on morphostratigraphic observations (e.g. glaciofluvial terrace sequences). In case of the "Hochterrasse" (≙ Higher terrace), the glaciofluvial gravel deposits have been tentatively correlated with MIS 6, attributed to the penultimate alpine glaciation. To assess these claimed-to-be-older parts of the terrace stratigraphy of the NAF, luminescence dating offers a tempting method. We have investigated the luminescence properties of coarse grain (100-200 µm) quartz and feldspar of multiple sampling locations in three neighboring valleys. This was done in regard to establish a dating procedure that can be applied to glaciofluvial sediments of the NAF in order to systematically compute the depositional ages of the gravel bodies. The 50 °C IRSL and 225 °C post-IR (pIRIR) signals of feldspar and the 125 °C OSL signal of quartz were investigated. Thermal transfer tests, dose recovery preheat plateau tests and laboratory fading tests were conducted. Particular attention was paid to the luminescence intensities of quartz and feldspar, as significant differences between samples were recorded. Luminescence intensities of feldspar of the Ybbs and Steyr valley can amount up to only a tenth of the intensity shown by feldspar of the Traun and Enns valley.

One problem that arises when dating glaciofluvial sediments from this area is the inconsistency of ages. What is striking from the so far completed measurements is that calculated quartz OSL ages are in agreement with uncorrected feldspar IRSL ages. However once corrected for fading, the IRSL ages are consistent with pIRIR ages, but are higher than the quartz ages. Possible explanations are either a thermal instability of the quartz OSL signal or overestimation of the pIRIR signal due to incomplete bleaching. To assess this discrepancy, bleaching experiments to investigate pIRIR residuals were conducted and the long-term thermal stability of quartz was explored using LM-OSL measurements.

Post-IR IRSL dating of a 100 m long lake core from Laguna Potrok Aike maar lake (Argentina): insights into bleaching history

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A luminescence chronology is developed for a 100 m long lake core (5022-1D) from the Laguna Potrok Aike maar lake in Argentina. The work is carried out as part of the international research initiative “PASADO” (Potrok Aike Maar Lake Sediment Archive Drilling Project), within the framework of the International Continental Scientific Drilling Program (ICDP).

Because of unsuitable quartz OSL characteristics, sand-sized K-feldspar extracts were used and the dose was measured using a post-IR IRSL ($pIRIR_{290}$) measurement protocol. Using this approach we access a stable signal and thus avoid the ubiquitous problem of signal instability in feldspar dating. Extensive laboratory tests (including dose recovery) show that the chosen $pIRIR_{290}$ protocol is applicable to these samples.

Unfortunately the stable $pIRIR_{290}$ signal is significantly more difficult to bleach than the unstable IR_{50} signal. We identify the less well-bleached layers in our core using a new criterion based on this difference in relative bleaching rates; the ratio of the $pIRIR_{290}$ and IR_{50} equivalent doses is used to identify and reject 14 poorly bleached layers out of 35. The resulting age-depth profile is self-consistent, increases smoothly with depth and is in good agreement with independent age control based on volcanic ash layers (Reclús, Mt Burney and Hudson tephras) at the top and in the middle of the core. Our new luminescence chronology suggests that the core reaches back to ~65 ka at ~96 m below the lake floor.

Does pulsed irradiation hold the key to using TT-OSL to date old samples?

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The first study introducing thermally transferred optically stimulated luminescence (TT-OSL) dating required a pulsed irradiation protocol in order for a sample taken at the Brunhes-Matuyama boundary to agree with independent age control (Wang et al 2006). No studies since then have been able to reproduce their results using constant irradiation (Duller and Wintle 2012). Pulsed irradiation was introduced in luminescence dating to resolve discrepancies between luminescence ages and independent age control. By dividing the laboratory irradiation into discrete pulses interspersed with heat treatments, pulsed irradiation is suggested to compensate for dose rate dependent competition effects (Bailey 2004). However, every inter-pulse heat treatment could potentially anneal part of the TT-OSL dating signal and thereby compensate for thermal instability. This study separates the effects of partial annealing and charge competition to determine what pulsed irradiation compensates for and whether it should be used in routine dating procedures. The results suggest that pulsed irradiation partially anneals the TT-OSL signal and charge competition effects are undetectable within error. This means that pulsed irradiation is not appropriate for dating using TT-OSL unless the age and thermal instability of the sample are known.

References:
Bailey, R.M., 2004. Paper I-simulation of dose absorption in quartz over geological timescales and its implications for the precision and accuracy of optical dating. Radiation Measurements 38, 299-310.
Duller, G.A.T., Wintle, A.G., 2012. A review of the thermally transferred optically stimulated luminescence signal from quartz for dating sediments. Quaternary Geochronology 7, 6-20.
Wang, X.L., Lu, Y.C., Wintle, A.G., 2006. Recuperated OSL dating of fine-grained quartz in Chinese loess. Quaternary Geochronology 1, 89-100.

A Bayesian framework for luminescence ages

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Bayesian statistics are a powerful and flexible means of quantitatively applying known information about a process or site (the "prior") to the measured data (the "likelihood"), in order to obtain a more precise age (the "posterior"). These methods allow a range of sophistication in the construction of mathematical priors, from the use of relatively simple stratigraphic information (Rhodes et al. 2003; Bouzouggar et al. 2007; Barton et al. 2009) to more complicated probability distributions derived from various statistical analyses (Cunningham and Wallinga, In Press). Importantly, such models can be used to incorporate information about the stratigraphic order and robustness of a priori data in a transparent manner, and they also allow sensitivity testing. Though still seldom used for luminescence dating applications, current Bayesian methods might be fruitfully applied to a number of common OSL/TL issues. OxCal, a free Bayesian modeling program (Bronk Ramsey 2009a), will be used to demonstrate multiple analyses on both simulated and real OSL data sets. Applications include the incorporation of multi-grain and single grain data, the exclusion or weighting (Bronk Ramsey 2009b) of potentially unreliable dates (e.g. due to saturation, possible sampling problems, or borderline dose recoveries), the incorporation of dosimetry results and uncertainties, and input of stratigraphic relationships (Bronk Ramsey 2008). Both single sites and regional chronological frameworks will be considered, focusing on the growing database of dated Middle Palaeolithic sites in North Africa.

References:

Barton, R.N.E., Bouzouggar, A., Collcutt, S.N., Schwenninger, J.-L., Clark-Balzan, L. (2009). OSL dating of the Aterian levels at Dar es-Soltan I (Rabat, Morocco) and implications for the dispersal of modern *Homo sapiens. Quaternary Science Reviews.* **28**: 1914-1931.

Bouzouggar, A., Barton, N., Vanhaeren, M., d'Errico, F., Collcutt, S., Higham, T., Hodge, E., Parfitt, S., Rhodes, E., Schwenninger, J.-L., Stringer, C., Turner, E., Ward, S., Moutmir, A., Stambouli, A. (2007). 82,000-year-old shell beads from North Africa and implications for the origins of modern human behavior. *PNAS*. **24**: 9964-9969.

Bronk Ramsey, C. (2008). Deposition models for chronological records. *Quaternary Science Review.* **27**: 42-60.

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Bootstrap likelihoods of the Minimum Age used to incorporate fluvial samples into a Bayesian chronological model

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Optically Stimulated Luminescence (OSL) dating has enormous potential for interpreting fluvial sediments, because the mineral grains used for OSL dating are abundant in fluvial deposits. However, the limited light exposure of mineral grains during fluvial transport and deposition often leads to scatter and inaccuracy in OSL dating results. Excessive scatter in the OSL ages can make it difficult to incorporate them in multi-method chronologies.

We argue that scatter between OSL ages is due to inadequate assessment of the uncertainty associated with an OSL age. We propose a new approach, in which the sensitivity of the minimum age (Galbraith et al., 1999) to each datapoint is tested with a bootstrap procedure. Each bootstrap sample also uses a different value for σ_b, drawn from a predefined distribution. Alternative outcomes are represented in the bootstrap distribution, and the likelihood of each outcome can be estimated using a nested bootstrap (Cunningham & Wallinga, 2012).

The generation of bootstrap likelihoods permits Bayesian methods to be used to help interpret partially bleached OSL data. Bayesian chronological models can provide an objective way of identifying outliers at sample or sub-sample level. The combination of bootstrap likelihoods with Bayesian chronological models may provide more robust OSL chronologies for fluvial sediment, and allows OSL ages from partially bleached samples to be combined with other age information.

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A new measurement system for luminescence dating - LEXSYG

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A highly flexible modular system for a variety of luminescence measurements used in dating application and luminescence research was developed. The LEXSYG systems provide standard measurements like Thermoluminescence (TL), Optically Stimulated Luminescence (OSL) and Infrared Stimulated Luminescence (IRSL), but also Infrared Radiofluorescence (IR-RF). A basic measurement chamber can be equipped with a variety of modules for irradiation, luminescence stimulation and detection.

The measurement chamber has a capacity of 80 cups/discs and is designed for vacuum/inert gas use. Samples are stored independent from the measurement section and hence sample change is possible at (nearly) any time, while radiation cross-talk, a common problem affecting the accuracy of luminescence dating, is avoided. The Beta (Sr-90) irradiation unit provides a homogeneous irradiation field with deviation across the sample area (10 mm diameter) of < ±3 (about ±2% at 8mm) and allows RF imaging (8mm). Sample heating (TL/preheat) can be performed up to 700°C. There several possibilities of OSL excitation by lasers and LEDs (850nm / IRSL; 532nm & 475nm / green & blue OSL; UV) which homogeneously illuminate the sample area for the stimulation of quartz and feldspar. The lasers can be used independently/simultaneously in CW or modulated mode. The instrument configuration presented has 2 PMT (one standard bi-alkaline and an IR-sensitive cooled tube) and a cooled EMCCD based detection units. While the PMTs are used for conventional (small) aliquot measurements, the latter can carry out spatially resolved (resolution c. 16 µm/Pixel) / single-grain measurements of hundreds of grains at once. Two automatic optical filter changing units adapt relevant PMT or imaging optics (EMCCD) at the same time. Luminescence detection windows can be set from UV to NIR and new optical filter-combinations have been tested for particular emission wave-bands and luminescence types of feldspars and quartz to perform high efficiency luminescence measurements for experimental work and routine dating applications. Furthermore all detectors can be changed automatically between the TL/OSL and RF position also within a measurement sequence, allowing a maximum flexibility and high throughput. A solar light simulation unit allows mimicking of different natural bleaching modes with variable wavelength spectra of samples within the chamber.

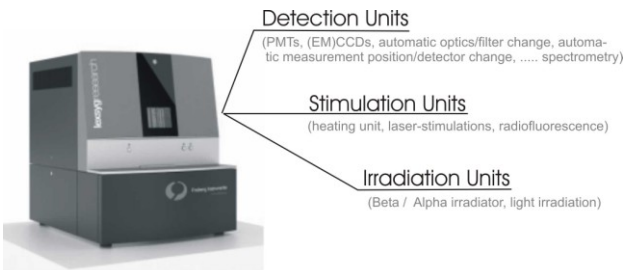

Figure 1: lexsyg - luminescence measurement system.

Application of single grain quartz OSL and TT-OSL to sediments at Kalambo Falls: How far can we go?

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The Palaeolithic site of Kalambo Falls in the north of Zambia was the subject of a major excavation by J.D. Clark in the 1950's. A rich palaeolithic tool record was recovered, but the value of this record was limited by the lack of chronological information available for the site. Four sub-sites make up the Kalambo Falls site, and all are located within 1 km of each other. In 2006, one of these sub-sites was re-excavated (Barham et al., 2009), allowing examination of the stratigraphic context and allowing collection of samples for luminescence dating.

The Kalambo river flows through the site, and many of the sediments were deposited by fluvial activity. Dose distributions in the single grain quartz OSL measurements of the youngest sediments are consistent with incomplete bleaching. However, the residual doses obtained are typically less than 10 Gy, and for older sediments the impact of incomplete bleaching becomes insignificant. Many of the older samples have a high proportion of grains which are saturated, but in all cases some grains give finite D_e values, making it feasible to calculate single grain quartz OSL ages. However, it is not clear at what point these ages become unreliable – if 50% of the grains are saturated, can one use the remaining 50% to date the sample?

This paper reports the results of applying the approach described by Duller (in press) based on the Fast Ratio to assess D_e reliability, and also explores the use of thermally transferred OSL (TT-OSL) at this site.

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Sedimentary Logging and Luminescence dating of the Kapp Ekholm Site, Svalbard

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The reconstruction of the glacial history of the Arctic is a key issue in enabling an understanding of the causes and dynamics of natural climate change. Considering this, from a sedimentological perspective, the section at Kapp Ekholm is unique within the central region of the Svalbard Archipelago (Mangerud and Svendsen, 1992) and thus is regarded as one of the key stratigraphic sites on Svalbard (Mangerud *et al.,* 1998).

At Kapp Ekholm the stratigraphy consists of four distinct cycles of sediments each consisting of glacial sediments overlain by upward-coarsening glacio-marine and marine sediments. These represent four ice advances separated by marine inundation of the fjord system (Mangerud *et al.,* 1998). Previous work recognizes three major Weichsalian glaciations and one Saalian on Svalbard, but evidence of older glaciations has recently been confirmed at a different section at Leinstranda (Alexanderson, 2011).

This work is being conducted within the scope of the Kapp Ekholm project (RIS ID 2562) and entails further detailed sedimentary logging of sections at Kapp Ekholm and luminescence dating aiming to conclusively date the glacial advances represented. Disagreement occurs in previously published work with both interpretation of the stratigraphy and the dates obtained (Forman, 1999). This highlights the necessity to re-date these sediments, as there have been a number of recent methodological improvements in luminescence. Preliminary dating on the site in 2007 shows disagreement with Mangerud *et al.* (1998). This is partially attributed to use of the MAAD method, on a number of samples, which fails to overcome the underlying problem of incomplete bleaching. Mangerud *et al.* (1998) also used the SAR method on some samples but it is predicted that the method will not yield the same results here due to the methodological improvements. Here, samples of sandy layers will be analyzed at Stockholm University using SAR protocol on quartz and feldspar with conventional IRSL/OSL, post IR and TT-OSL techniques to establish sequence and timing of glacial events at Kapp Ekholm.

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Optically Stimulated Luminescence Dating of the Heelbo Alluvial Slope Deposit, Free State Province, South Africa

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The gullied sedimentary sequences of the alluvial slopes located on the farm, Heelbo in the Free State Province, South Africa have experienced climatically controlled histories of erosion, sedimentation and pedogenesis. Extreme sedimentation is assumed to have occurred during relatively arid climatic intervals, when decreased vegetation cover provided little surface protection. In contrast pedogenesis occurred during humid intervals when vegetation cover was restored, the land stabilized and the uppermost gravely sands weathered to form soils. The Heelbo hillslope deposit has been reworked through fluvial processes particularly flash flood events, and 7 samples were collected to constrain the timing of the depositional events through optically stimulated luminescence dating.

The equivalent dose (De) values were determined for each sample and their distributions were analysed to determine the extent of zeroing of the quartz grains. One of the problems inherent in optically stimulated luminescence relates to the zeroing of the quartz grains through the complete emptying of the electron traps. In fluvial environments such as Heelbo it is possible that due to the reworking of the sediment not all quartz grains were sufficiently and equally zeroed. This is reflected as multiple populations in the distribution of the equivalent dose (De) values and is quantified mathematically by the calculation of the overdispersion. Two of the seven samples returned high overdispersion values of 43% and 87%.

The palaeosols ages range from 0.595 ka to 3 665 ka and the results indicate that at least 3 depositional events are recorded within the sedimentary deposit. These dates provide a chronology of these successive hillslope events which can possibly relate hillslope instability to climatic forcing factors.

OSL dating of Late Pleistocene aggradation-incision transition in the Negev Highlands, Israel

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A sharp transition from deposition of late Pleistocene fine-grained sediment to intensive incision which forms alluvial channels is observed in some arid and semi-arid regions. The aim of this study is to frame in time this important transition, and test whether it happened simultaneously in different drainage basins in the Negev Highlands, southern Israel. Three low-order drainage basins of different sizes were selected for this study. Alluvial terraces were mapped and sampled for OSL dating.
The main alluvial terrace in all three basins is constructed of similar sedimentary units: a basal fluvial loess unit; a middle gravel unit that truncates the loess unit at different heights; and an upper loess unit of fluvial-aeolian origin. The transition between the lower loess and the overlying gravel demonstrates the beginning of incision, and its continuation is marked by the deposition of the lower, younger, gravelly terraces.

Twenty-three sediment samples were dated using OSL. Quartz grains were extracted and measured using the SAR protocol. Dose recovery test and recycling ratios all show that the SAR protocol is appropriate for these samples. All the samples, except for those collected from the upper loess unit, are fluvial sediments and are poorly bleached; particularly the gravel samples. To isolate the best bleached fraction, 1 mm aliquots (for the young samples) or single grains (for the older samples) were measured, and the De were calculated by the central age model (CAM) or the finite mixture model (FMM), respectively.

De distributions were used to assess depositional regimes: the mostly well bleached lower loess unit was deposited by flows of moderate energy. The gravel units were deposited during flood events, in which the grains were poorly bleached. Only in the largest basin (10 km^2), the transport distance allowed adequate bleaching. The smallest basin (0.7km^2), which best recorded the transition event, yielded the most poorly bleached samples due to short transport distances. These samples were difficult to date.

OSL ages range from ~70 ka to ~1 ka. At all sites the ages, within errors, are in stratigraphic order. Overall, similar units from different basins have similar ages. The lower fluvial loess was deposited between 70 and 30 ka; the gravel unit was dated to 14-10 ka; the uppermost loess unit was deposited between 13 and 6 ka, indicating deposition after incision began. The OSL ages place the transition from aggradation to incision between 30 ka and 14 ka, corresponding to the glacial termination, MIS 2.

Time-Resolved Luminescence Spectroscopy on the St Andrews Luminescence System

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In 2001, St Andrews received the chassis of the Radio-, Cathodo-, Thermo-Luminescence spectrometer system built by Peter Townsend at the University of Sussex. The system had the ability to resolve spectrally the light emitted (250-800 nm) from samples following or during electron and/or X-irradiation from temperatures between 20 and 700 K. As part of an upgrade of the system, we installed new detectors with enhanced responses at low light levels and the ability to label individual photon arrivals with time signatures. We have also added banks of LED's to the sample chamber, which, with time gating, allow time-resolved light irradiation. The many components of the system have been integrated into a single control programme written in house using LabVIEW.

A number of experiments have been performed on the system:

1. Continuous Wave (CW) cathodoluminescence (CW-CL) and X-ray luminescence (XEOL or RL) as a function of temperature. If the irradiation is performed prior to temperature ramping, then ThermoLuminescence (TL) is observed. By ramping the temperature during irradiation, composites of CL and XEOL with TL are observed. Repeating the experiments show modification of the sample during heating.
2. Time-resolved PhotoLuminescence (TR-PL) can be achieved by pulsing LEDs and examining the arrival times of photons as a function of wavelength. The response times resolved by the detectors are of the order of 100s of ns, and similar to the phosphorescence times of the LEDs. The system resolves light emissions with lifetimes in the μs to s lifetime range.

Further experiments are now feasible with minimal development of the system. TR-CL is possible using the detectors by flicking the beam off sample by pulsing the lenses in the electron optics. These include spectrally resolved TR-OSL using a combination of X-irradiation, stage temperature ramping and pulsed irradiation by LEDs. Other suggestions for experiments are welcomed. We are testing the capabilities of the system to see whether sensitivity is sufficient for TL and OSL on dim samples and/or whether different forms of data processing can enhance signal to noise in the least intense samples.

A modified multi-step post-IR IRSL protocol for dating of Holocene sediments using K-feldspar

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The multi-elevated-temperature post-IR IRSL (MET-pIRIR) method was initially proposed for dating of old samples (Li and Li, 2011; Fu et al., 2012). A modified MET-pIRIR protocol is proposed here for dating of young samples within the Holocene using K-feldspar, which utilizes a moderate preheating of 200°C for 60 s, and a narrower IR stimulation temperature increment of 30°C. Using this method, the residual doses of the MET-pIRIR signals are less than 1 Gy. Holocene aeolian samples from Northern China were applied using the modified MET-pIRIR method. Age plateaus from 140°C to 170°C were found, which gave ages consistent with the quartz OSL ages. The method is further simplified to a three-step pIRIR protocol. The first IR stimulation at elevated temperature (110°C) is used to remove the fading affected signal. This is followed by two steps of IR stimulation at 140 and 170°C for De measurement and age-temperature plateau check. The three-step pIRIR method has minimized the experimental procedures, while keeps the age plateau test.

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Introducing an R package for luminescence dating analysis

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For routine luminescence dating applications the commonly used Risø readers are bundled with analysis software, such as *Viewer* or *Analyst*. These software solutions are appropriate for most of the regular dating and publication jobs and enable assessment of luminescence characteristics and provide basic statistical data treatment. However, for further statistical analysis and data treatments, this software may reach its limits. In such cases, open programming languages are a more appropriate approach. Here, we present the **R** package 'Luminescence' for a more flexible handling of luminescence data and related plotting purposes using the statistical programming language **R**. The **R** language as well as the package and the source code are provided under the General Public License (GPL) conditions and are available for free. The basic functionality of the package is described along with three application examples. This package is not an alternative to the existing software (*Analyst, Viewer)* but may provide a collection of additional tools to analyse luminescence data and serve as a platform for further contributions.

Comparing single grain and small aliquot quartz OSL and feldspar IRSL dating applied to Alpine glaciofluvial sediments from the Swiss Midlands

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We investigate the luminescence properties of samples taken from sand lenses in the proglacial outwash of a piedmont glacier that reached the Swiss midlands during the last glacial maximum. Independent age control for the test site at Gebenstorf is given by an AMS radiocarbon age on a horse-*tibia* found within the gravel pit. Furthermore geological constraints limit the depositional age to between 30 and 20 ka.

The aim is to identify the best approach for the dating of glaciofluvial sediments in the area that should be applicable to samples from similar settings. To do so a variety of tests on coarse grains (200 - 250 µm) of quartz and feldspar are performed using single aliquot as well as single grain techniques. D_e-distributions are compared with regard to bleaching characteristics of the two mineral fractions. Deconvolution of CW-OSL decay curves confirms a domination of the fast component in the OSL signal from quartz. The chemistry of single feldspar grains, in particular the K content in different grains, is investigated using wavelength dispersive spectrometry (electron microprobe). The applicability of fading tests and the $pIRIR_{225}$ approach are also tested.

Preliminary OSL dating of an active fault movement from 1858 using several quartz grain sizes

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Quartz grains contained in an active fault are useful OSL dating mineral to estimate the final earthquake occurrence. We have performed a tentative OSL dating of an active fault named “Atotsugawa fault” in central Japan, which was the origin of “the Hietsu epicentral earthquake” hit in 1858 with a M.7.3 rating on the Richter scale. The sample was collected carefully from a fault gouge 20 cm in width in an outcrop covered with a blanket to prevent solar bleaching. Quartz grains were obtained after a series of chemical treatments including HF etching to remove the surface of the quartz grains and to eliminate clay minerals from the sample. Quartz grains were separated by sieving into four grain sizes, 63-125, 125-250, 250-355 and 355-500 micrometers in order to examine equivalent doses (D_e) for each grain size. An OSL reader, composed of Nichia NSPB310B LEDs and Hamamatsu R585s PMT with a Schott DUG11 detection filter, was newly designed by MEDEC K.K. of Japan. The installation of a small X-ray generator (Varian VF50J-WS) in the OSL reader was used to carry out the SAR method. An aliquot with 10 quartz grains was used to determine a value of D_e. The D_e distribution was examined using 30 aliquots for each grain size. A dose recovery test showed that most samples had satisfactory values within a range of 0.9-1.1 showing the reliability of using quartz grains for OSL dating. The shine-down curve showed that the OSL signals of all grain sizes are composed of mainly fast components. The expected D_e is about 0.26 Gy led by the annual dose of 1.68 mGy/a evaluated by a ICP-MS measurement of U, Th and K content and the cosmic-ray and water content of the sample. The D_e distribution of each grain size can be separated into a few groups. The main D_e peaks occurred at a range between 0.10 and 0.40 Gy close to the expected D_e, followed by one in the range of 0.70 to 0.90 Gy and then over 1.7 Gy. This result showed that OSL dating is a practical method for evaluating an active fault movement and fault gouges are including quartz grains being un-reset natural OSL signals at the fault activity.

Modeling the overdispersion in single-grain dose populations arising from heterogeneous potassium distribution in sedimentary media.

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The complexity of single grain dose distributions of quartz results from a combination of intrinsic and extrinsic factors. Intrinsic sources of overdispersion have been identified in gamma dose experiments, one of the simplest types of laboratory controlled experiments (e.g. Thomsen et al., in press). When single grain OSL methods are applied to geological or archaeological sedimentary samples, external factors such as partial resetting of luminescence signals before burial, or beta dose-rate heterogeneity must be taken into account. We have accumulated considerable experience over the last ten years in the measurement of doses from individual grains, but little effort has been put into understanding the grain-to-grain distribution of dose rates (Mayya et al., 2006; Chauhan et al., 2011). The conventional approach still consists of deriving an average infinite-matrix dose rate, with little or no consideration of variability induced by the spatial heterogeneity in dose rate.

In this study, we have used a specifically designed Geant4 code to simulate the emission of beta particles from potassium feldspars in sedimentary media. The dose-rate model has been calibrated and tested on a sand sample from a 4 ka (~5 Gy) beach-ridge for which we are confident that incomplete bleaching does not play a significant role. We evaluate the ability of the model to explain the variability observed in our experimental OSL data, and then apply it to samples from an archaeological site. The model, its performance and its predictions are presented. We then discuss the potential of the model to explain the increase in overdispersion observed between laboratory gamma-dosed and naturally-dosed equivalent dose distributions from geological/archaeological samples. The implications for identifying and resolving bleaching problems are discussed.

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The theory of trapped charge thermochronometry

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Processes such as mountain uplift or valley incision typically involve the progressive cooling of deeply-seated rocks as they move towards the Earth's surface. The knowledge of a rock's cooling history may be obtained through various temperature-sensitive dating proxies (thermochronometers), each recording the time since the rock cooled below a certain "closure temperature". Owing to their low thermal escape barrier energy (typically 1-2 eV), trapped charge dating systems (e.g. optically stimulated luminescence, thermoluminescence, electron spin resonance, exo-electron emission, etc.) exhibit closure temperatures in the range of 60 – 0 °C; this opens up a new area of low-temperature thermochronometry, allowing for the first time to quantify landscape change on a sub-Quaternary timescale (e.g. in response to glacial cycling.)

In the current work, we present a consistent theoretical basis for incorporation of trapped charge thermochronometers into the existing family of fission track and noble gas (e.g. $^{40}Ar/^{39}Ar$ and U-Th/He) thermochronometers. We explore how limited storage capacity for the radiogenic products, and the possibility of their significant escape at typical surface temperatures, affect the closure temperature in these systems. We conclude by discussing method limitations, sampling strategies, and the additional information that can be extracted from borehole and deep tunnel samples.

Does higher resolution OSL sampling lead to better chronological interpretation of aeolian dunefields?

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Dunefields of semi-arid environments are key indicators of prehistoric drought because aeolian sedimentation occurs during periods when stabilizing vegetation is diminished. Luminescence dating is particularly useful for deriving chronological data on dune activity in these environments, and, therefore, useful in determining past episodes of drought. Scores of dune activation chronologies currently exist for the North American Great Plains, however, the distribution of these ages does not reflect the full spatial and temporal record of aeolian activity in the region. The aim of recent research has been to supplement this record by producing new, high-resolution chronologies of yet un-studied dunefields.

One such study was that of Halfen et al. (2012), which investigated the Hutchinson dunes, a small (400 km^2), isolated dunefield in east-central Kansas, USA. Sixty OSL samples were collected and analyzed from a total of 31 dune sites. Dunes were sampled both 1 m below their surface and at depth, directly above the underlying alluvial contact, resulting in the highest spatial resolution sampling of any dunefield in the Great Plains (1 sample per every ~13 km^2). A core question of this research is, however, whether high-resolution OSL sampling leads to improved chronological interpretation of aeolian dunefields in the Great Plains? Our data suggest that increased sampling resolution does add additional clarity to regional dune activation chronologies, and, therefore, to our understanding of past climatic events. Further, high-resolution stratigraphic sampling adds temporal clarity on dunefield geomorphology, such as dune sedimentation and migration rates. Issues of scale, still remain important, and high-resolution sampling does not address sub-century correlation of dune activity across the Great Plains. Our recommendation, based on a future of limited time and resources, is that Great Plains dunefields need not be sampled to such a high-spatial extent to provide century-scale correlation to regional changes in climate. Conversely, high-resolution stratigraphic sampling is necessary to acquire age data on other geomorphic variables in dunefield development.

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The age, genesis and significance of the sterile dune sand at Blombos Cave, South Africa.

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The MSA sequence at Blombos, a prominent South African Still Bay site, is famously terminated by an archaeologically sterile dune sand dated to c.70 ka (Henshilwood et al., 2002). This sand may constitute either a site specific cause for abandonment, or be representative of a regional re-mobilisation of coastal sediment. The former scenario allows a deeper understanding of the nature of the Blombos record, whereas the latter scenario indicates substantial changes in the palaeogeography of the landscape occupied by Still Bay producing populations. Distinguishing between these scenarios is important since Jacobs et al. (2008) demonstrate an abrupt disappearance of the Still Bay industry at c.71 ka. Here, we present optically stimulated luminescence ages for both the dune sand from around Blombos, and apparently contemporaneous cemented dunes along the south coast. The implications of these ages for the environmental conditions surrounding the end of the Still Bay industry in the southern coast of South Africa will be discussed.

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Exploring luminescence measurement level approaching best the expected D_e in complex postglacial sediments of Wauwilermoos, Swiss Plateau.

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The location Wauwilermoos provides a range of complex postglacial and colluvial sediments. While attempting dating of these samples, discrepancies of the resulting D_e estimates were observed depending whether small aliquots (SA), large aliquots (LA) or single grains (SG) were used. While SG yielded D_e estimates best supporting the palaeo-environmental and archaeological expectations, the aliquot measurements failed, with SA yielding the worst results. This observation contradicts the usual assumption that in alpine foreland SA would result in reliable D_e because they approach measurements obtained using SG.

In order to explain this phenomenon we have determined a) the real number of grains on variously sized aliquots (packing ratio) and b) the proportion of bright to dim grains present in the alpine quartz extract. The analysis of the probability for bright and dim grains to be present on large or small aliquots revealed that SA's hardly contain bright grains whereas LA more often contain bright grains. It is expected that this influences the grade of D_e averaging on aliquots.

Hence we suggest that the knowledge of the packing ratio and the proportion of active grains in a given sample are very important in the choice of the used aliquot size to optimise the proportion of active grains on a single aliquot and the counting statistics.

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The post IR IRSL characteristics of polymineral fine grained sediments from Darhad Basin and Lake Hovsgol, Mongolia

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The elevated temperature post-IR IRSL (pIRIR) procedure was applied to the polymineral fine grained sediments from Lake Hovsgol, Mongolia. We applied four preheat / stimulation temperatures to a typical sample in search for appropriate measurement conditions (preheat / stimulation temperature: 250 / 225^{o}C, 280 / 250^{o}C, 300 / 270^{o}C and 320 / 290^{o}C). All dose recovery ratios are calculated after subtracting a residual dose of 6~12Gy which is significantly high for our samples. Dose recovery ratio of $pIRIR_{290}$ is 20% larger than unity, however that of $pIRIR_{225}$ lies within 10% of unity. Therefore, it is suggested that lower preheat temperature ($pIRIR_{225}$) is more suitable for pIRIR protocol than higher one ($pIRIR_{290}$). For SARA $pIRIR_{290}$ and conventional IRSL procedures, the initial preheat at a high temperature (ex. 320^{o}C) causes the sensitivity change. The g-value of $IRSL_{50}$ signal prior to measurement of pIRIR signal is obviously higher than that of pIRIR signal. However, g-values for pIRIR procedures are concordant within the error range. The fading uncorrected $pIRIR_{225}$ ages are in good agreement with fading corrected $IRSL_{50}$ ages. Both ages are also corresponding with age model based on several ^{14}C ages. Therefore, $pIRIR_{225}$ protocol can be applied to estimate the sedimentation age of lake sediments as well as ^{14}C dating.

Constraining Late-Quaternary sea-level change in the Arabian/Persian Gulf using optically stimulated luminescence

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Remnants of a previous marine highstand are situated around the southern coast of the Arabian Gulf in the form of zeuge landforms. These zeugen are comprised of a cross-bedded aeolianite (Ghayathi Fm.) capped by a thin (<1m) shallow marine limestone (Fuwayrit Fm.). The limestones are currently some 3-6 m above present sea-level and this has been taken as evidence for their last interglacial age (i.e., MIS 5e), when eustatic sea-levels were higher than the present day. Actual dating of the formation has been problematic with a majority of previous endeavours at dating the Fuwayrit Fm. proving unsuccessful and questions raised over the reliability of ^{14}C ages applied to the Fuwayrit Fm limestone. However, a recent study by Wood *et al.* (2012) used a combination of quartz OSL and ^{14}C dating to place the Fuwayrit Fm. age at 17-30 ka, during the preceding glacial. As global eustatic sea-level was approximately 100-130 metres lower than present during MIS 2, this implies that rapid uplift of the region has since occurred to bring the current Arabian coastal margin to its current elevation, for which no other evidence exists.

To investigate this paradox, samples of both the Fuwayrit Fm. and underlying Ghayathi Fm. were collected from sites near Abu Dhabi, UAE, for analysis using quartz optically stimulated luminescence (OSL). The SAR protocol of Murray and Wintle (2003) was applied to coarse-grains of quartz. Whilst analysis is still ongoing, preliminary results suggest that the Fuwayrit Fm. is older than suggested by Wood *et al.* (2012). However, there may be significant variability in the equivalent doses obtained from the sample, and there appears to be significant dose dependency on integration limits used in calculation of equivalent dose. These and dose rate data will be investigated in detail in the poster in order to better constrain the depositional age of the aeolianite and cap-limestone, and hence determine the sea-level history of the Arabian coastal margin.

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Success in dating late-Pleistocene dunes in central Alaska using a Post-IR IRSL protocol

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While not as widespread loess deposits, aeolian dunefields are prominent features of Alaska from the North Slope, Seward Peninsula, to the central lowlands, and beyond. These dunes not only provide a wealth of paleoclimatic information such as wind direction and magnitude, but they contain a rich archaeological record, e.g., the recent discovery of a late-Pleistocene (11.5 ka) child cremation and residential site within a loess-mantled dune (Potter et al., 2011).

The Wood River dunefield, located southwest of Fairbanks, Alaska in the Tanana River Lowlands, consists of >40 stable, forested dunes, most of which tested positive for surface and near-surface cultural material. Luminescence samples were collected from the upper 2 m at the crest of ten of these dunes. Initially, samples were IRSL dated and corrected for anomalous fading following the Huntley and Lamothe (2001) method, though this approach produced fade-corrected ages which were far too young (i.e., ~5–9 ka) given the archaeology and 14C age acquired by earlier researcher at other dune sites. Samples were re-analyzed using the Post-IR IRSL protocol described by Roberts (2012), resulting in older, more reasonable ages, ranging mostly from ~11-15 ka. At the one site where coincidental ^{14}C charcoal-derived ages were available, agreement of the new luminescence ages was quite good, e.g. 13.5 ka (^{14}C) vs. 13.11 ka (revised IRSL protocol). Accordingly, this new protocol will be used in the dating of samples to be collected during the 2013 field season from the larger Nenana River dunes and Kantishna sand sea west of the Wood River dunes. Sampling will be done systematically with depth and dune form.

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Dating polymineral fine grain loess deposits using the post-IR $IRSL_{290}$ protocol: A cautionary tale

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The post-IR $IRSL_{290}$ protocol has recently been advocated as "A robust feldspar luminescence dating method for Middle and Late Pleistocene sediments" (Buylaert et al., 2012). However, application of this protocol to polymineral fine grained sediments from Late Pleistocene loess deposits from Washington State, USA, consistently results in significant age overestimations, relative to the existing quartz luminescence chronology. The post-IR $IRSL_{225}$ protocol returns ages that are largely consistent with the existing quartz chronology and whereas this protocol successfully recovers dose, the post-IR $IRSL_{290}$ protocol consistently returns dose overestimations. We present various experiments which identify the cause in these samples as sensitivity change during the initial luminescence signal measurement (L_n), which the SAR protocol is unable to correct for. We highlight the importance of pre-heat plateau dose-recovery experiments, from which the optimal measurement parameters for individual samples can be identified.

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Sous le Pont d'Avignon: OSL dating of sediments in the lower Rhone at Villeneuve les Avignon

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OSL investigations provide a chronological framework to reconstruct the fluvial dynamics of the Rhône River at Avignon (south France) through the late Medieval to early modern periods, and support geo-archaeological investigations of the Pont d'Avignon. Diachronic analysis of historic cartographic data has provided a relative chronology for geomorphic changes of the River Rhône, which with historical accounts of the bridge; provide a link between the construction, utilisation and abandonment of the bridge with historic flooding events. Five boreholes were drilled through the west bank of the Rhône to a depth of c. 8m, in the vicinity of Villeneuze-lés-Avignon. Detailed luminescence investigations were carried out on two cores, which contain (from top down) several metres of silty clay, interpreted as post-abandonment fills, several metres of sands, interpreted as late channel fills, and gravels at c. 7.35 m, reflecting the main fill. Initial luminescence profiling, using portable OSL equipment, was used to characterise the stratigraphy in each core. It was possible to correlate between the lithostratigraphic units identified in each core on the basis of their luminescence characteristics. Additionally, the field profiles indicated the parts of the cores that may be better suited for dating, and showed that similar signal levels might be expected above and beneath the main sand accumulation, suggesting a high rate of sedimentation and a relative short chronology. Laboratory analysis comprised luminescence screening measurements on 15 selected samples, to assess sensitivities and approximate stored doses, and quantitative OSL SAR analysis on 9 dating samples. The laboratory profiling results implied that the age progression above and beneath the sand accumulation was modest, reinforcing the notion that the chronology was short.

The individual dates fall into the late medieval to early modern period of French history, with statistical combinations pointing to an early to mid 17th century accumulation of sediment. These dates are consistent with the interpretation that the sediment accumulation is associated with destructive floods, in the period associated with the end of the Little Ice Age and the warming period that followed it. It was during this period that the Pont d'Avignon was finally destroyed and that attempts to repair the broken arches were abandoned. The OSL investigations have indicated a compelling link between historic flooding events which led to the destruction of the Pont d'Avignon and the sediment deposited in over bank deposits as these floods retreated.

A Risø XRF attachment for major element analysis of aliquots of quartz and feldspar separates

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In luminescence dating the target minerals are usually quartz and feldspar; typically, these are separated using physical and chemical pre-treatments. However it is unusual to analyze individual aliquots of these extracts, and so the variability in individual chemical composition is unknown. In particular, the K concentration of K-rich feldspar extracts is usually assumed to be around 12% (e.g. Huntley and Baril, 1997), but this assumption is rarely tested.

Here we describe an XRF attachment to the Risø TL/OSL reader, consisting of an X-ray tube (40 kV, 4W, Amptek Inc.) and X-ray spectrometer (X-123SDD, Amptek Inc.) installed on the alpha irradiator position; the reader chamber can operate under vacuum and so the spectrometer can measure low energy X-ray emissions from light elements (sodium, aluminum and silicon). XRF measurement options have been incorporated into the Sequence Editor; as a result XRF analysis can now be included at the end of a luminescence measurement sequence without additional user involvement. Separate analyzing software loads the BIN file, displays the spectra graphically, converts the intensities of relevant peaks to weight percentages (assuming the main minerals are quartz and feldspar), and displays the final feldspar components on a ternary diagram.

Calibration using various well-known compounds (Na/K/Ca carbonates, Al_2O_3 and SiO_2, mixed and glassified) is described. Results from four certified natural feldspars (Na-rich: BAS-375, NIST 99b and K-rich: BAS376, NIST 70a) are used to verify this calibration. Finally we present typical results from a number of routine quartz and feldspar analyses.

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The a-value of polymineral fine grain samples measured with the post-IR IRSL protocol

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Feldspar is a bright dosimetric material that saturates at higher doses than quartz. However, feldspar dating is hampered by anomalous fading that potentially leads to age underestimations. With the development of the post-IR IRSL (pIRIR) protocol by (Thomsen et al. 2008), a method was suggested to circumvent this limitation by measuring at higher temperatures and detecting a signal component that is less affected by fading. Since then, an increasing number of dating applications have been presented applying the new protocol to different grain size fractions. In contrast to coarse grain feldspar, for the fine grain polymineral fraction α-radiation has to be accounted for. Due to different ionisation densities, the luminescence per Gy induced by α-radiation varies from that of β- or γ-radiation, expressed as α-effectiveness, also known as the a-value. It is further known that the a-value depends on the applied stimulation method (thermally vs. optically). Recently, pIRIR dating studies using polymineral fine grains assumed an identical a-value for the IRSL signal at 50 °C and the pIRIR signal at higher temperatures (e.g. 225 °C). However, this assumption remains to be tested. To prove the hypothesis that a common a-value can be used for both the IR and the pIRIR signals, we carried out an empirical study on five polymineral fine grain samples. Using the post-IR IRSL protocol the a-values were measured with three different methods of signal resetting (optical bleaching, end of SAR cycle, heating). In addition, additive α- and β-irradiation induced growth curves were determined for three samples and fitted with single saturating exponential functions. Based on the fitting parameters synthetic growth curves for both types of irradiations were constructed to investigate the development of the a-value and its differences between the IR_{50} and the $pIRIR_{225}$ signal with increasing dose. For all five investigated samples we found significant differences, 0.02 and higher, in the a-values determined from the IR_{50} and $pIRIR_{225}$ signals. The synthetic a-value deduced from additive dose response curves seems to confirm this observation, even for the non-linear dose region. In summary, our results indicate that the practice of using a common a-value should be carefully re-considered.

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Dead time correction and sample camera for the Risø TL/OSL Reader

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We introduce two recent modifications to the TL/OSL Reader: a dead time correction for the photon count rate recorded by photomultiplier, and a camera focussed on the disc positions on the sample wheel. The relevance of these modifications to luminescence dosimetry applications will be discussed.

It is well known that the count rate of a photomultiplier tube has an upper limit determined by the time required to generate a pulse. For the Electron Tubes 9235QB15 used in the Risø TL/OSL reader significant non-linearity sets in for count rates above about 5 Mcount/s. A simple dead time correction model has been used to extend the range over which the response is linear to at least 40 Mcount/s. The verification and the practical implementation of this correction will be discussed and the benefits of this improvement in dynamic range will be illustrated.

Some researchers make images of single grain discs or multi-grain aliquot disc and/or cups after luminescence measurement. This may be to relate any observed luminescence peculiarities to optical or morphological characteristics of the sample disc, or to determine statistical parameters such as grain size and number. To make this operation more convenient, and to minimise any disturbance of the sample disc, it is now possible to take such images automatically without removing the disc from the reader. This has been achieved by adding a 5 Mpixel sample camera to the reader at the X-ray or α irradiator position, focussed on the sample wheel passing below, and a “Sample Photo” command to the Sequence Editor. Illumination is provided by a dedicated white LED illumination ring. The practical implementation will be presented, together with an illustration of the use of the attachment.

Investigating the potential of HCl-only treated samples for range-finder OSL dating

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Rapid sample preparation and measurement protocols for optically stimulated luminescence (OSL) dating have previously been investigated as a method of increasing the throughput of samples (e.g. Durcan et al. 2010; Roberts & Duller, 2004; Roberts et al. 2009). Here, we investigate the potential of dating samples treated only with hydrochloric acid (HCl) for providing accurate range-finder ages. The equivalent dose (D_e) is underestimated for older samples using a standard single aliquot regenerative (SAR) protocol, but measurement of the [post-IR] OSL signal (e.g. Roberts and Wintle, 2001) provides D_e estimates within 10% of the 'target D_e' for the majority of samples. The application of standardised growth curves (SGCs) is investigated, with no difference in the accuracy of the D_e estimate when using a regionally based or regionally-independent curve For these dune samples, the quickest preparation and measurement procedure from which accurate D_e estimates can be obtained is treatment with HCl, measurements of the natural and a regenerative [post-IR] OSL L_x and T_x, and calculation using a SGC. The potential application of this rapid preparation and measurement protocol is discussed in relation to sand dune dating studies.

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Testing TT-OSL and Post-IR IRSL methods on old (<780 ka) lacustrine deposits from Nihewan Basin (northern China)

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The Nihewan Basin is located in the Sanggan River drainage in Hebei Province, northern China. It is famous for its thick late Cenozoic, fossilferous, lacustrine stata and a large number of Paleolithic localities (e.g. Barbour, 1924; Zhu et al., 2001). The Xiaochangliang archaeological site has been successfully dated using magnetostratigraphy methods and the section extends beyond the Brunhes/Matuyama (B/M) boundary (Zhu et al., 2001). This section provides a possibility of testing the accuracy of thermally transferred OSL (TT-OSL; Wang et al., 2006) and post IR-IRSL (pIRIR; Thomsen et al., 2008) methods on old samples. With this objective, luminescence dating samples were collected above the B/M boundary from a 20 m thick sequence of lacustrine and aeolian sediments.

TT-OSL signals from fine-grained quartz, and pIRIR signals from polymineral fine grains and coarse grains of K-feldspar were used for dose estimation (after Liu et al., 2012 for TT-OSL and Buylaert et al., 2012 for pIRIR). All the tests relevant to the SAR procedure were carried out successfully. It is observed that the TT-OSL signals near the B/M boundary give dose estimates smaller than the expected doses - in the deeper samples in this section, the TT-OSL D_e does not change significantly from 5 m to at least 19 m (8 samples), even though the TT-OSL signal is far from saturation on the laboratory growth curve. On the other hand, the post-IR IRSL signals in the deeper samples are indistinguishable from saturation on the dose response curve. We present these results and discuss the implications for our understanding of the stability of TT-OSL and pIRIR signals.

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Post IR IR and TT-OSL dating of South Australian palaeodunes – How far back can we push the time scale?

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Palaeodunes in the semi-arid western Murray Basin (South Australia) provide evidence of more arid conditions in the past. The linear dunes have already been dated using quartz OSL (Lomax et al. 2011). The OSL-ages of more than 100 samples imply that dune formation was probably not continuous, although no palaeosols were found in the dunes to support this statement. Breaks in the dune record seem to coincide with more humid phases found in other geo-archives, whereas phases of pronounced dune sand accumulation coincide with arid conditions. Thus, the dunes of the Murray Basin seem to have a high potential for reconstructing palaeoenvironmental conditions. Dose rates in the region are generally low (~1 Gy/ka), and with an approximate saturation of the quartz OSL signal at 200 Gy, ages of up to 200 ka can be obtained. Many of the dune sands however were older than 200 ka and cannot be securely dated using OSL. Thus in a further attempt, TT-OSL dating of quartz and post IR IR dating of feldspar were applied to the oldest samples. The results imply that dune formation was initiated at least 300 ka ago. The potential of the two 'new' methods for dune sands will be evaluated with respect to signal bleaching, size of residuals and signal saturation, providing interesting outcomes for future dating of 'old' dunes.

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Over-dispersion: a potential sedimentological proxy for underwater sediments?

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Equivalent Dose (D_E) over-dispersion values have been used as a measure of inhomogeneitiy in the natural palaeo-dose of sedimentary deposits being optically dated. Such heterogeneity could be due to an array of causes, from insufficient zeroing during transport and/or deposition, to geo- or bio-turbation processes after burial, but also unexplainable intrinsic additional scatter in the data or extrinsic micro-dosimetry variations. As proven by many authors, environments where sediments are well exposed to daylight at deposition (e.g. aeolian and some coastal) do not show extreme over-dispersion values but rather well clustered D_E values as noted by the various probability-distribution plots used. The degrees of variance and skewness of Gaussian or relative-probability distributions are intrinsically related to the scatter or over-dispersion factor. Hence, the latter could be used to differentiate between depositional mechanisms and/or environmental settings, provided that the primary heterogeneity cause could be isolated from the others (i.e. insufficient zeroing).

The shallow underwater Mediterranean waters offshore Caesarea Maritima, Israel, were selected as a suitable environment for this experiment as they have proven to show minimal to no turbation processes affecting the sub-bottom layers. The single-aliquot regenerative-dose (SAR) protocol was used to measure the Optically Stimulated Luminescence (OSL) signals from single grains from a suite of underwater sediment samples identified as tsunamigenic, storm-laid or deposited under normal-weather conditions. The samples were collected by various means: from long-vertical hydraulic percussion cores (at 14 and 30 m depths) to small horizontal tubes pushed into freshly excavated (with telescopic caisson) underwater sediment walls (between 2 and 12 m depths). Over-dispersion analyses were conducted on each one of the samples measured. Based on the pre-established over-dispersion value of 20% (or less) as a representative figure for a single-dose population (Duller, 2008), the underwater sediment samples could be distinguished into at least three different groups leading to the possibility of using over-dispersion as a sedimentological proxy.

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Independent dating methods versus pollen chronology – establishing reliability

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Optically stimulated luminescence (OSL) dating was applied to a sedimentary core drilled in lake sediments situated in the southern Alpine foreland of Northern Italy. OSL ages obtained on the fine grain quartz fraction underestimate, by ~ 30 ka, the age-depth model derived from pollen and extending back to the Last Interglacial. As an earlier application of OSL to another site in the region produced similar results, and in the light of increasing literature concerning the underestimation of fine grain quartz of even younger age, the assumption was made that the OSL data was unreliable. One should not forget, however, the inherent problems of chronologies derived from variations recorded in proxy records: the age-depth model was obtained through a process of first tying climate fluctuations recorded by pollen to events recorded in European stalagmite and marine records, and ultimately correlated with isotopic events recorded in the Greenland ice cores and tuned to orbital cycles. Radiocarbon ages supported the pollen chronology down to 30 ka but, below this point, displayed an underestimation compared to the pollen, which was attributed to modern contamination, and led to the rejection of radiocarbon ages lower down the core. More recently, the geochemical identification of a known-age tephra has been found to be in excellent agreement with both the radiocarbon and the OSL ages, and require that this data is revisited. The pollen record appears to be robust in this particular case, and it is not always easy to reconcile OSL ages with the accompanying palynological interpretation. This study is an excellent example of a Quaternary site where a multidisciplinary approach has been taken to the research, and offers a valuable opportunity to test several methods. While it has produced the enviable result of the agreement of three completely independent dating methods, it is not easy to resolve the discrepancy between these and the pollen interpretation. The strengths and weaknesses of the OSL, together with the other methods, are presented in order to garner the opinion of other dating specialists. At most, it is hoped to identify the most likely depositional age of the sediments and validate the application of particular methods. At least, it is important to make available the results so we are better informed when presented with similar situations in the future.

Single-grain OSL dating of the Middle Palaeolithic site Lusakert, Armenia

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Lusakert is a Middle Palaeolithic rockshelter in the Armenian Caucasus with an abundance of obsidian artefacts. The only existing chronological control for the site is an Ar-Ar date of ~200 ka on the basalt layer in which the rock shelter is formed. Previous chronological studies indicate the possibility that Neanderthals were present in the Southern Caucasus at a later date than elsewhere in Europe (Adler et al. 2008). However, a more widespread application of modern chronological techniques is required to make sense of this complicated story. The presence of Late Middle Palaeolithic tools gives Luskert the potential to provide a robust chronology for this time period in the southern Caucasus. In turn the archaeological record in Armenia could provide crucial clues for deciphering the patterns of Neanderthal social interaction amongst themselves and possibly also with modern humans.

Single-grain Optically Stimulated Luminescence (OSL) dating was undertaken on three archaeological units from the interior of the rockshelter. Initial analysis showed that the samples have a low quartz content, low intrinsic brightness, and are dominated by a relatively slowly decaying OSL component. We explore a range of measurement and data analysis strategies to circumvent these limitations. The implications of these data for the OSL dating of archaeological sites in the southern Caucasus will be discussed.

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Comparison of the performance of age-models in the OSL dating of historical and modern-age flash-flood sediments

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When dating young samples likely to have been incompletely bleached at burial there is a risk of overestimating the burial age. At least in principal, this problem can be avoided by measuring single grains individually and by applying suitable statistical models designed to identify the grains most likely to have been well-bleached at burial. In this study, we compare OSL ages derived from both single grain and multi-grain (~30 grains) measurements obtained from eight recent quartz samples (40-1000 years) extracted from a sequence of flash flood deposits, whose ages are known from historical records. Single grain gamma dose recovery experiments were used to quantify the smallest uncertainty with which a single grain dose value can be measured (~20 %). We have used various statistical approaches (robust statistics, CAM, CAM_{UL}, MAM, MAM_{UL} and IEU) to derive burial ages. Most single grain dose distributions contain a significant number of negative dose values preventing the simple application of CAM and MAM. However, we show that by applying an exponential transformation of the data before input to the models, indistinguishable results are derived using CAM and CAM_{UL} as well as MAM and MAM_{UL}.

For all these samples we find that the CAM significantly overestimates the known age. Excluding the youngest (~40 years) the ratio of measured to expected age for MAM and IEU are 0.89 ± 0.11 (n=7) and 0.99 ± 0.05 (n=7), respectively. Both methods overestimate the youngest sample age by about 40 years. For small aliquot measurements we obtain a good agreement between measured and expected age using IEU (1.12 ± 0.09, n=6) when excluding the two youngest samples (~40 and 70 years), which overestimate the known age by ~3 times.

Bleaching residuals of $IR_{225°C}$/post-IR signals in fluvial sediments

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In this poster, we present the results of experiments performed on fluvial sediments from the Dordogne valley (France) and aimed at determining the Equivalent Dose (ED) of residual $IR_{225°C}$/post-IR signals obtained after bleaching. This signal, first studied by Thomsen et al. (2008), and then by Buylaert et al. (2009) is known to be less affected by anomalous fading than the classic $IR_{50°C}$ signal, but seems also to be less bleachable. For relatively young deposits, the question of the residual signal is then of paramount importance. Here, we report on a comparison of results obtained after the feldspars grains were either exposed to a solar simulator or to natural conditions, for different durations.

The feldspars grains were extracted from fluvial sediments whose age control is given by C-14 ages - between 9 and 10 ka CAL BP- (Bertran et al. 2012). The fading correction of Huntley and Lamothe (2001) helps to discuss the validity of the substraction procedure.

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Results from a Laboratory Intercomparison Based on a Beach-ridge Sand from Skagen (Denmark)

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We describe results from a laboratory intercomparison sample based on a quartz-rich aeolian and/or coastal marine sand ridge from the Skagen peninsula, northern Jutland (Denmark). About 200 kg of sand was sampled at night from a single beach ridge. The sand was homogenised using a cement mixer and packed in ~700 moisture and light-tight bags, each of ~250 g. The quartz luminescence characteristics are satisfactory (e.g. good dose recovery). Our own equivalent dose determinations and radionuclide concentrations for twenty of these bags demonstrate that our standard is homogeneous. Analysis of all the responses gives a mean dose (supplied quartz) of 4.58 Gy, σ=0.40 (n=26), to be compared to the mean dose (self-extracted quartz) of 4.52 Gy, σ=0.55 (n=21). The mean age is 4.04 ka, σ= 0.69 (n=22), i.e. a relative standard deviation of 17%. We present an analysis of all the important quantatative and qualitative responses we have received since 2007 and discuss the implications for our dating community.

Testing post-IR OSL, pulsed OSL and post-IR IRSL protocols for fluvial samples from Tiszasas (Hungary)

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The paleo-river network of the Carpathian Basin differed significantly from the modern river network. At the end of the Pleistocene the drainage systems of the paleo-Danube and -Tisza Rivers have substantially changed due to the higher rate of subsidence along the margins of the Great Hungarian Plain (Nádor et al., 2007, Gábris and Nádor 2007).

The study area is located near Tiszasas, close to the modern channel of the Tisza River. The profile is located in a sand pit and contains mostly fluvial sand layers in a thickness of 6 m. 10 sand samples were collected from the profile for luminescence dating and 3 samples for heavy mineral analysis to distinguish between the deposits of the different palaeo-Rivers. The aim of the study is to make age constraints for the re-arrangement of the drainage pattern of the area using luminescence dating.

Single aliquot regeneration dose protocol (SAR) has been applied on coarse grained quartz samples for Optically Stimulated Luminescence (OSL) dating to determine the equivalent doses of the samples. Due to the strong feldspar contamination of the quartz samples different protocols (postIR-OSL and pulsed OSL) were tested to find the best way to determine the D_e-s of the samples. Besides, post-IR IRSL (Infrared Stimulated Luminescence) protocol (Buylaert et al, 2009; Thiel et al., 2011) was applied on feldspar samples, too. Post-IR IRSL test measurements resulted in better dose-recovery ratios for pIRIR-225 signals than for pIRIR-290 signals and both showed negligible fading ($g_{2\ days}$: ~1%/decade). Therefore, the pIRIR225 protocol was chosen for further measurements. Different luminescence ages obtained on quartz and feldspar are compared and discussed.

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Late Pleistocene to Recent uplift of coastal terraces in Northern Cyprus constrained by OSL

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The Kyrenia Range in Northern Cyprus has been uplifted from below sea level to its current height of ~1000m over the past 2.5Ma. As a direct consequence of this rapid uplift we find a series of geomorphological erosional terraces on both the northern and southern flanks of the mountain range. These terraces have formed as a consequence of the interplay between tectonic forces and global sea level change. By studying the sedimentology and geomorphology of these terraces we hope to better understand the driving forces of the uplift and hence the regional tectonic setting of the Eastern Mediterranean during the Quaternary. Luminescence methods will be applied to the youngest of these terraces deposits, which are of suspected Tyrrhenian and Neotyrrhenian age, locally known as the Kyrenia and Koupia terraces respectively. The Kyrenia terrace is a regional depositional surface that dominates the northern side of the range and is comprised of a combination of marls, braided streams, palaeosols, calcarenites and aeolinites. The Koupia terrace is found along the northern coastline and is predominantly made up of aeolinites with some minor calcarenite. Here, we report on our initial observations, which were made on location with a SUERC portable OSL reader. 12 profiles were taken through sedimentary sequences from both terraces, covering the full range of lithologies. It was found that each terrace had its own distinctive set of luminescence characteristics, allowing the units to be correlated east-west along the length of the range, and on its northern and southern slopes. Interestingly, the results demonstrated a clear difference in signal strength between the two terraces, with the younger Koupia terrace giving IRSL and OSL net signals several orders of magnitude larger than the older Kyrenia terrace. In situ gamma spectrometry measurements were made at all sites, indicating no significant change in dose rate between terraces. Given the stratigraphic and sedimentological relationships between the two terraces, one may have expected the higher terrace to yield higher luminescence signals. We have now implemented a programme of further study to determine the mineral characteristics of representative sediment from both terraces, to assess whether a switch in provenance, or sensitisation of the dosimeters during transport, could explain the apparent discrepancy. Finally, this project aims to date these terraces using SAR OSL.

Thermo- and optical luminescence of fault gouge: experimental results

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Recognizing past events of intense shear along faults is essential for better understanding of earthquake physics and seismic hazards. Yet, only a few geological features, e.g., pseudotachylites, have been accepted as indicating intense shearing conditions. We present here an attempt to develop a new method to recognize past earthquakes. We hypothesize that intense shear would modify the luminescence of the gouge particles which formed during the shear event. To test this hypothesis, we conducted a series of experiments on a laboratory fault that was sheared by a rotary friction apparatus, which is capable of simulating earthquake conditions. The experiments were conducted under dark conditions on samples of sandstone and quartzite composed mostly of quartz. The experiments were run under slip velocities of 1 to 20 cm/s, normal stresses 0.15 to 2.8 MPa, and for few centimeters to 170 meters. The gouge formed during the shear process was collected after slip distances of few centimeters to few hundreds of meters. These samples, as well as the original non-sheared rocks, were analyzed by OSL and TL.
The results show complete or partial OSL and TL signal resetting. Further, TL results of pulsed annealing experiments provide a series of signals that can be related to the maximal temperature on continuous heating. A complementary experiment of sandstone grinding showed partial OSL signal resetting.
The results suggest that OSL and TL signals are likely to be reset by the fast shear of earthquakes. Furthermore, resetting increases with inverse relation to the grain-size of the sheared material under the same conditions. This indicates that fine grains, which are reset more easily, should be used for fault movement dating. Conductive heating was observed to be a crucial mechanism for resetting, but cannot solely explain the entire resetting. Mechanical grain damage was observed to be a resetting mechanism for OSL when tested separately, and cannot be rejected to influence during shear simulations. The total energy dissipation was the only experimental loading condition to be systematically proportional to the TL/OSL resetting intensity.

Third millennium B.C. carnivore traps from the Negev Desert (Israel)

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Stone-built installations, called 'leopard traps', are found throughout the Middle East deserts. They have generally been considered to be recent, built by Bedouin or other local communities, for trapping carnivores. Here we present the first optically stimulated luminescence (OSL) ages for sediment infill within two of these structures, from the hyper-arid 'Uvda Valley, southern Negev, Israel.

Two well-preserved traps, one small and one large, were selected. Fine, loess-like aeolian sediment cover the floors to a height of 15-20 cm and it post-dates the structure. Samples were collected as spits of 3-4 cm until the floor was reached.

Conventional multi-grain SAR measurements on quartz show large scatter of D_e values. Single grain measurements were used to detect older, pre-construction grains and obtain ages for only the post-construction sediments. One trap was constructed before ~ 1600 years ago while the other before ~ 5000 years ago. Our results demonstrate that the traps are ancient and were already in use before the 3rd millennium B.C.

Testing the potential of 'Natural Sensitivity Correction' methods

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It is well known that the recombination OSL sensitivity of a quartz sample can change significantly during preheat, an effect which is accounted for in Single-Aliquot Regenerative-dose (SAR) protocol (Murray and Wintle, 2000). Recently, Singhvi et al. (2011) have demonstrated using 110°C TL peak as a proxy for OSL that a significant sensitivity change can occur during the first OSL readout (L_N) using the blue LEDs; this implies that the natural test dose signal (T_N) does not reflect the sensitivity of the natural (L_N). Any error arising from such an effect will not be reflected in a dose recovery experiment because laboratory dose is delivered after blue light or daylight exposure. Singhvi et al. (2011) proposed a modified SAR procedure (NCF-SAR) that uses the ratio of the 110°C TL peak before the first preheat and after the natural OSL readout (Natural Correction Factor or NCF) as a measure of the sensitivity change during the measurement of L_N. Their results show that the D_e estimate can shift significantly (up to 60 %) when the correction is applied.

To test the potential usefulness and the accuracy of the NCF-SAR we carried out comprehensive experiments using the SARA-SAR approach (Wallinga et al., 2002). We tested different measurement set-ups (aliquot sizes, doses) and we calculated the over-dispersions in the distributions; i.e. the inter-aliquot scatter that is not explained by the measurement uncertainties. In the course of our investigations we further modified the NCF-SAR protocol. The outcome of this research will be presented and discussed during the meeting.

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Extending the numerical chronology of lacustrine records using luminescence dating

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Lakes can preserve important terrestrial records of palaeoclimate and environmental change, with some sites capable of providing high-resolution records with essentially continuous sediment accumulation over time. In certain settings, very long sediment cores can be retrieved. However, although these thick sedimentary deposits can reveal detailed fluctuations in palaeoenvironmental proxies, these proxy data are of limited value without a reliable chronology. Thus far, lake-floor sediment chronologies have been chiefly reliant on radiocarbon dating, which has typically restricted the ages generated to the last ~40 ka. However, this time range frequently describes only the upper portion of the sediment record, and the deeper portions of the sedimentary record are assigned ages either by extrapolation (thereby assuming a constant accumulation rate, and a continuous sediment record with no hiatus'), or by tuning one of the palaeoenvironmental proxies to orbital insolation. Clearly, a preferable approach is direct numerical dating of the sediments throughout the entire sedimentary sequence.

In this paper, polymineral fine-grain [post-IR] IRSL luminescence ages are presented for a 90m sediment core from Lake Tana, Ethiopia, with a comparison against radiocarbon chronology for the upper sediments. Lake Tana lies in a climatically sensitive region; the luminescence ages generated provide one of the longest independently dated lacustrine chronologies for East Africa, spanning the entire period of human evolution.

Optically stimulated luminescence dating of Late Holocene marine sediments from Loch Sunart, Scotland, UK

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The determination of OSL ages spanning 10^1 – 10^5 years for quartz and polymineral fine-grained sediments are routine for many environments. ^{14}C and oxygen isotope chronologies are commonly used to date marine sediments, and unlike marine ^{14}C dating, OSL dating is unaffected by marine reservoir effects which can lead to significant uncertainties in age determinations, and has a significantly wider age range than the younger and older limits of radiocarbon dating. While OSL dating may not improve on the precision offered by Late Quaternary oxygen isotope chronologies, it can provide an independent validation of their accuracy or an alternative method when no δ^{18}O stratigraphy is available. Despite the apparent potential of OSL to date marine sediments, its application has been relatively restricted and no applications to sea loch sediments have been published.

A suite of Late Holocene polymineral fine-grained samples from fjordic sediments in Loch Sunart, Scotland, have been dated using OSL methods. Loch Sunart was selected because there is an existing ^{14}C chronology for sediment core GC01-PM06 (Cage and Austin, 2010) which provides a test of OSL dating methods in this environment. One half of the core has been stored under chilled and light-free conditions at St Andrews. Four samples were taken from this half of the core at equivalent depths to those originally sampled for ^{14}C dating.

The OSL ages overestimate ^{14}C depositional age by ~200 years. The causes of this age overestimation are uncertain, but may relate to partial resetting of the OSL signal prior to deposition, or alternatively to disequilibria in radio-isotope decay chains. Future investigations using fine-grained quartz may circumvent the limitations of partial bleaching encountered here, as quartz are known to bleach (reset) more rapidly than feldspars (Godfrey-Smith et al., 1988), which contribute the dominant signal recorded in polymineral analyses. OSL dating of older sea Loch sediments is likely to prove more successful, as the proportion of total age that partially bleached residuals comprise is reduced.

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A comparison of single-grain and small aliquot dating of fine sand from Cyrenaica, northern Libya.

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Over the last decade, single-grain studies have significantly enhanced optically stimulated luminescence dating of quartz from Quaternary and archaeological sediments. However, single-grain dating is time consuming and requires specialised equipment, leading a number of authors to advocate measurement of small, multi-grain aliquots, as a viable alternative. In this study, we compare single-grain and small aliquot data from four samples from Cyrenaica, northern Libya. Discrepancies are found between the results obtained using these two techniques, which we attribute to: (1) grains with poor luminescence properties, which are present in the small aliquot data but not the single-grain data and (2) averaging effects in multi-grain aliquots. We suggest that small aliquot measurements are not always an appropriate alternative to single-grain analysis, and that small aliquot datasets should be treated with caution.

Post Stimulation Phosphorescence (PSP) as a luminescence profiling indicator: application to the Villeneuve-lez Avignon sediment cores

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Luminescence profiling[1-9] is increasingly used to help understand sediment evolution and guide sampling for dating. In earlier work[5] CW mode intensities were discussed as combined proxies for age, luminescence sensitivity (including attenuation effects) and dose rate. Depletion rates encode information about sample attenuation coupled to signal inheritance, and IR/OSL ratios may also encode mineralogical information. Inversions, discontinuities, and mixed layers are frequently encountered in screening work and are usually informative. Post-stimulation phosphorescence (PSP) is further considered here, illustrated by sediment cores from the Lower Rhone.The magnitudes of PSP, following dark count subtraction, can be expressed relative to prior stimulated luminescence signals, thus reducing the influence of sample sensitivity on PSP profiles. It is argued that such ratios vary in response to the coupling between deep and shallow traps within the luminescence-sensitive minerals in the samples, and are thus sensitive to diagenetic origins. The ratio IR-PSP/OSL-PSP may additionally be influenced by relative spectral absorption properties of the bulk sediments being examined. In the Rhone cores PSP intensities and their ratios show stratigraphically significant variations, which link both to sediment grain size, and to the chronology of the materials associated with LIA flood deposits.

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Thermal stability of OSL components of silex (amorphous/microcrystalline SiO_2)

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During the last decade, it has been confirmed that the quartz OSL signal is composed of several distinct components featuring different bleachability and dose-response characteristics, but also varying thermal stability. The benefit of high saturation dose levels of the slow components is for sediment OSL dating often superseded by their poor bleachability. However, when dating fired materials such as silex artefacts, complete signal resetting is expected, what would potentially allow taking advantage of the dose-response of slow components to increase the upper dating limit for Palaeolithic occupation layers. Since the OSL signal of silex has been poorly studied, this contribution addresses its composition and the thermal stability of components as a major requirement for their use in archaeological dosimetry.

Three of the four investigated samples revealed a component in their LM-OSL curves of similar bleachability as the quartz fast component, while this component is missing for the most amorphous sample. A rather continuous LM-OSL signal – lacking distinct peaks – follows towards increasing stimulation times which could be best fitted to four components. Their thermal stability was tested by component-resolved pulse-annealing experiments. Except for the “fast-like” component, thermal erosion mostly begins at temperatures ≤ 200 °C, and the linearly decreasing pulse-annealing curves indicate that non-first-order processes are involved (Singarayer 2002). Since these hard-to-bleach components proved to be thermally unstable over geological timescales, only the first (“fast-like”) component was studied further. Its thermal lifetime was determined by fitting of component-resolved pulse-annealing data, short-shine pulse-annealing data as well as using the varying heating rates method (Li et al. 1997, Singarayer 2002). Obtained trap parameters *E* and *s* for this component from each of these methods give coherent results, enabling to calculate a lifetime sufficient to cover Quaternary/Palaeolithic events. When using OSL for dating archaeologically heated silex, it must be kept in mind that the internal dose rate requires the determination of the alpha-efficiency of each individual sample, which might be different from that for TL. Moreover, many of the tested archaeological samples did not show a “fast-like” component, thus impeding the use of OSL for age determination.

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A comparison of postIR-IRSL$_{290}$ and postIR-OSL derived dates from coastal deposits on NW Sardinia (Italy)

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This paper presents a comparison of quartz SAR post-IR OSL stimulated and postIR-IR$_{290}$ ages performed on a variety of Late Pleistocene shallow marine deposits cropping out along the N-W Sardinia coast. Given the samples stratigraphy, Mediterranean sea level curve and the Sardinian tectonical stability, the deposits must be formed during sea level highstands of Marine Isotopic stage 5 (135-75 ka).

Samples were prepared under red light conditions to extract quartz and K-rich feldspar grains (ρ<2.58 g/cm^3) in the size range of 90-250 µm. The Post-IRIR$_{290}$ protocol applied to feldspars consisted of a preheat of 320° C for 60 s, an IR stimulation at 50°C 200 s and a final IR stimulation at 290° for 200 s to measure the IRSL signal. Test dose measurement received the same preheat treatment as natural and regenerative dose. Each SAR cycle was finished by a 325° C for 200s to minimize any rebuilding of charges. The post-IR OSL protocol consisted of a preheat of 160-260° C for 10s, an IR stimulation at 50° C for 40s followed by a blue LED stimulation at 125° C for 80s. Dose rates (Dr) are based on a combination of thick source beta counting for the beta component and field gamma spectrometry for the gamma dose. The internal potassium beta dose in feldspars was assumed at 12%. Post-IRIR$_{290}$ results are corrected for a 10 Gy residual dose as determined from a modern beach sample.

Resultant post-IR SAR quartz ages are much younger than those determined from Post-IRIR$_{290}$ feldspar from the same samples. Moreover quartz derived ages must under-estimate true burial age as they fall within sea-level low stands despite being of marine origin. Post-IRIR$_{290}$ ages are much closer to expected ages falling at MIS5 interglacial and interstadial highstands. The cause of the apparent quartz under-estimation was tested. The reliability of the post-IR OSL protocol was tested by performing a dose recovery test on various samples which showed an average ratio of 1.06. Moreover, the quartz OSL signals appeared well behaved and SAR growth curves were below the saturation level (2D0; typical De values were around 50Gy). Whilst OSL shine down curves showed an enhanced medium/slow component early background subtraction made little substantive difference to calculated ages.

In conclusion, although quartz IR-OSL SAR measurements passed all standard tests, obtained ages seem to be underestimating the expected age and they are not in agreement with the Mediterranean sea level curve. Instead, K-feldspar ages are much closer to the expected ages.

Late Pleistocene-Holocene development of the Maros alluvial fan, Hungary-Romania, revealed by luminescence dating

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The fan of River Maros with its 10 000 km^2 is among the largest alluvial landforms in the Carpathian Basin. On its present surface numerous channel generations can be seen with very different dimensions and pattern, suggesting dramatic shifts in the course and discharge of the river in the past.

Our aim was to reveal the dynamics of morphological development along with the time of significant changes in fluvial activity. For paleodischarge reconstruction morphometric, geophyisical and sedimentological techniques were applied, while the dating of channel generations and major avulsion events were made using optical dating.

More than 10 meandering, braided and anastomosing channel generations were separated and 30 representative medium and coarse sand OSL samples were collected. In terms of braided sections the last time of acivity, in terms of meandering and anastomosing sections the full history of some representative curvatures were attempted to be revealed. In order to determine the adequacy of bleaching in the river system some present day, known age sediments were also dated.

For OSL measurements the standard SAR procedure was applied on either the 90-150 or 150-220 µm quartz fraction of the samples. Preheat and dose recovery tests were performed on 6 mm aliquots. Equivalent dose was determined by using 2 mm aliquots, nearly 30 % of which had such a low sensitivity that they could not be used for evaluation. Usually, from 96 aliquots around 40-50 passed measurement criteria, and these were used for various minimum age analyses.

Based on the results, the oldest detectable channels are braided, date back to 20-22 ka and occupy the northernmost part of the alluvial fan. Later braided and meandering patterns were alternating in time and main flow was gradually shifting by 18 ka to the axis of the fan. The rising of the Holocene brought a return to the northern territories, and melt water pulses from the Carpathians formed enormous braided feaures. With the last avulsion event around 9 ka the direction of flow shifted to the southern lobe. Following this event the river found its present day course gradually in the the axis of the alluvial fan. As a major conclusion we found that the Maros alluvial fan was formed much more dynamically and actively than it was previosuly assumed.

Grain-to-grain variability in residuals of the post-IR IRSL signal in K-feldspars

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The recently developed post-IR IRSL (pIRIR) protocol circumvents anomalous fading and is now widely applied for dating K-feldspar (Thomsen et al. 2008). In glacial environments quartz OSL signals are often dim making single-grain analysis difficult, whereas a brighter pIRIR signal is emitted from K-feldspars. However, residual doses up to 20 Gy (Thiel et al. 2011) and 25 Gy (Roberts, in press) have been reported for the $pIRIR_{290}$ signal in polymineral loess samples, and average 5 ± 2 Gy for coarse grain K-feldspars (Buylaert et al., 2012). The existence of residuals could be detrimental in single-grain analysis of incompletely bleached sediments. This study reports single-grain $pIRIR_{225}$ and $pIRIR_{290}$ residuals measured on grains of two aeolian dune samples after different intervals of optical bleaching in the solar simulator. As previously reported, $pIRIR_{225}$ residuals were smaller than the $pIRIR_{290}$ residuals. However, single-grain data demonstrates for the first time the large variation in the magnitude of the pIRIR residual signals for individual grains of K-feldspar. The implications of the highly variable residual levels observed in different grains will be discussed using dose-recovery experiments on one sample bleached in nature and another in the solar simulator to remove any pre-existing charge.

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Optically stimulated luminescence (OSL) as a chronometer for surface-exposure dating

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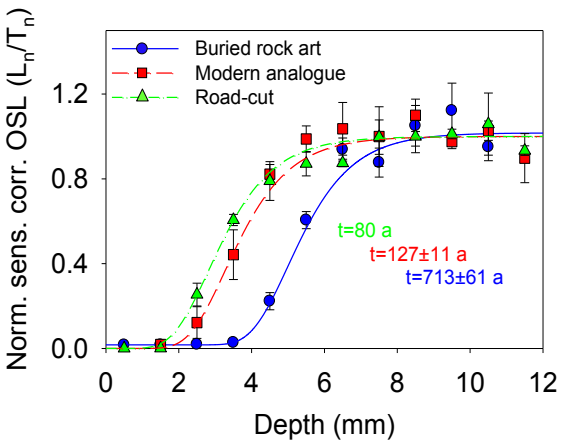
We develop a technique of surface-exposure dating based upon the characteristic form of an optically stimulated luminescence (OSL) bleaching profile beneath a rock surface; this profile evolves as a function of depth and time. Our model takes into account the effect of both bleaching and dose-rate. As a field illustration of this new method, a fossil exposure age of ~700 years was determined for a buried rock sample at Canyonlands, Utah, USA, which allowed us, for the first time, to constrain the time frame for the creation of the Barrier Canyon Style rock art to 800-1500 years B.P. (Sohbati et al., 2012a; Chapot et al., 2012). In another application of the model to quartzite cobbles from the Tapada do Montinho archaeological site (east-central Portugal), we were able to identify four events in the history of a single cobble; two exposure events of different time lengths and two burial events of 26 ka and 19 ka (Sohbati et al., 2012b). The new OSL surface-exposure dating method appears to have the potential to complement CN dating. This method has also implications for non-terrestrial dating.



Residual OSL profiles into Navajo Sandstone surfaces from the Canyonlands National Park, Utah, USA. The model fits are shown as curved lines. The longer the exposure, the farther into the rock the luminescence is reset. The known age (road-cut) sample has been exposed to daylight for 80 years (triangles). Using this as a calibration sample, the exposure ages of two other samples including a Barrier Canyon Style rock art (circles) were calculated.

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Quartz OSL and polymineral post-IR IRSL dating of the Irig loess profile in Vojvodina, Serbia.

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Loess sequences in the Vojvodina region of Serbia have recently emerged as some of the most important climate archives in Europe, yet their dating remains a challenge. Whilst quartz optically stimulated luminescence (OSL) is widely accepted as preferable for dating loess sequences, it is restricted to the last c. 50 ka due to saturation of the quartz dose response curve. To bypass this limitation, much previous dating work on European loess has relied on polymineral infrared stimulated luminescence (IRSL) dating at 50° C, as the IRSL signal saturates at considerably higher doses (up to ~2 kGy). However, this signal is known to exhibit athermal anomalous fading, requiring application of a significant correction that remains controversial in its accuracy beyond the linear portion of the dose response curve.

Recent work has demonstrated that the post-IR at 50° C IRSL signal measured at high temperature (e.g., 290° C; here termed post-IR IRSL) exhibits little or no fading and is a more reliable age-indicator in loess sequences (Buylaert et al., 2012). Here we apply a joint quartz OSL and HT-IRSL at 290° C approach to samples collected from the Irig profile just south of Fruška Gora, Vojvodina. Quartz ages are shown to saturate at c. 50 ka but generally match non-fading corrected post-IR IRSL ages to this point. Uncorrected post-IR IRSL ages also generally match expected ages based on the proposed chronostratigraphy to the base of the profile (c. 220 ka). However, the youngest post-IR IRSL age shows significant overestimation of the expected D_e based on quartz dating (45 vs. 20 Gy), and at two other points in the profile (bracketing the S1 soil) the post-IR IRSL ages show large age inversions and significant overestimation of expected age. These results, as well as fading, bleaching and dose recovery results, will be discussed in the poster.

Buylaert, J.-P., Jain, M., Murray, A.S., Thomsen, K.J., Thiel, C., Sohbati, R., (2012). A robust luminescence dating method for Middle and Late Pleistocene sediments. *Boreas* **41**: 435-451.

Progress towards absolute dating of calcium carbonate snail opercula: a potential chronometer spanning 3 million years.

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Stirling et al. (in press) have undertaken laboratory measurements which show that calcium carbonate snail opercula have excellent thermoluminescence (TL) properties: the trap associated with the TL peak at 325°C has a lifetime of ~10^{11} years at ambient temperatures, and this peak grows to doses of at least 6000 Gy. Based on initial estimates of the dose rate to these samples, this dose range and stability imply that these opercula have the potential to date events over the last 3 million years.

Protocols are already in place to measure the equivalent dose of these opercula using TL (Stirling et al. in press), and therefore at this stage the key challenges are to determine the dose rate that these carbonates receive during burial, and test the method on samples of known age.

This study firstly describes the generation of three dimensional representations of the opercula that are used in the program 'Grainer' (created by R. Nathan). Use of Monte Carlo radiation transport codes within Grainer result in modelled attenuation factors for alpha and beta dose rates. Secondly, equivalent doses and dose rates are determined for a limited number of known age samples to assess whether reliable absolute ages can be measured. Finally, remaining challenges in the development of this novel chronometer are discussed.

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Towards a better understanding of natural K-feldspar equivalent dose distributions

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Over the last few years, intensive work on luminescence dating of individual K-feldspar grains embedded in basal ice from Greenland has been undertaken (Thiel et al., 2009, 2010; DFG-funded project TH1651/1-1). The observed single grain dose distributions are skewed with tails towards larger doses, possibly indicating incomplete bleaching prior to deposition. However, it is also possible that the distribution shape is controlled by varying K-content (and thus internal dose rates to the individual grains; in ice the external dose rate is negligible), or by varying grain-specific fading rates. Thus the origin of these skewed distributions remains unclear.

To provide a better understanding of such natural dose distributions, IRSL (IR_{50}) and post-IR IRSL ($pIRIR_{290}$; Thiel et al., 2011; Buylaert et al., 2012) measurements were conducted on K-rich feldspar grains both from presumably well-bleached (aeolian) and from poorly bleached (glacio-fluvial) samples. Equivalent dose and fading measurements were made using either IR diodes (one grain per cup) or an IR laser (standard single grain disc). These measurements were accompanied by pulse-annealing and µXRF measurements to discriminate Na-rich from K-rich feldspar grains.

Here we present an overview of our data set and discuss possible interpretations of the observed dose distributions.

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Luminescence and chemical composition - two case studies using the new Risø XRF attachment

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The new Risø XRF attachment (Kook et al., this volume) allows for fast and efficient major elements analysis of both quartz- and feldspar-rich aliquots and thus opens new opportunities in luminescence studies such as quantification of feldspar contamination in quartz extracts and determination of K-concentrations, both on an aliquot by aliquot basis.

In our first experiments, we measured IR depletion ratios for aliquots of several quartz-rich extracts and quartz/feldspar mixtures; the same aliquots underwent XRF analysis immediately after luminescence measurement. Using this dataset we test (i) the hypothesis that the IR depletion ratio is the best indicator of feldspar contamination and (ii) the sensitivity of the XRF system to the presence of feldspar.

In a second set of experiments, equivalent doses on K-rich feldspar extracts were measured prior to XRF analysis. We examine the widths of the resulting age distributions calculated using two different dosimetries: (i) based on measured K-concentrations and (ii) assuming a constant 12.5% K in all aliquots (Huntley and Baril, 1997). These data are used to discuss the general validity of the assumption that the grains with the highest K-concentrations dominate the luminescence signal detected using blue filters.

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A chronological framework for Late Quaternary landscape evolution related to regional scale climatic change on Mallorca (Balearic Islands, Spain) using optically stimulated luminescence dating

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Coastal outcrops of Late Quaternary deposits in the north east of Mallorca are examined. The outcrops Es Barrancar and Cala Mata record a complex succession of alluvial fan deposition with a minor aeolian component, mainly deposited during the last glacial period.

A chronological framework is established using optically stimulated luminescence dating of 106-180µm quartz and feldspar grains. Ages were obtained using a quartz SAR protocol, and the $pIRIR_{290}$ SAR protocol for feldspar. The quartz luminescence is dominated by a high-sensitivity fast component, allowing the use of 3mm diameter aliquots. IR depletion ratios indicate that the quartz extracts had no significant residual feldspar contamination. Recycling values typically lay between 0.9 and 1.1, and a given dose of 50 Gy was recovered satisfactorily for all samples. Preliminary ages from a limited number of feldspar samples indicate good agreement with the quartz ages.

The fluvially reworked aeolianite units can be traced laterally along wide sections of the sea front outcrops, although they are truncated in places. Clusters of OSL ages from these units suggest at least two previously unrecognised periods of enhanced alluvial activity across the fan systems. One set of four ages cluster around 50ka, corresponding to the early part of MIS3. The second set of five ages appears to indicate intense reworking towards the end of MIS5b, or possibly MIS5a. The major reworking events have been interpreted by previous studies to have taken place during cold climatic intervals when vegetation was at a minimum and precipitation was highly seasonal, resulting in enhanced run off. The latest OSL results from this research appear to support this assertion.

Testing single-grain OSL methods using known age samples

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In many OSL dating studies using single grains of quartz it is assumed that much of the over-dispersion in equivalent dose distributions arises from external factors such as incomplete bleaching and sediment mixing. Various statistical approaches have been proposed to quantify the burial dose but little testing of these has been done using samples of known age. Here the most widely used of these approaches are tested against age control. Four OSL samples were collected in a rock shelter in central France, from a colluvial sediment with some evidence of ponding; ^{14}C and OSL quartz and feldspar (multi-grain large aliquot) ages of between 20 and 50 ka have been reported elsewhere (Aubrey, et al., 2012; Buylaert et al., 2012). These multi-grain quartz and feldspar ages agree with each other and with the independent C-14 age control, strongly suggesting that incomplete bleaching is not an issue for these samples and that we can be confident of the ages.

The minimum possible over-dispersion (determined using laboratory-bleached and gamma-dosed single grains) is ~18%, although there may be a limited dependence on given dose. The natural over-dispersion is ~40% and according to the decision tree proposed by Bailey and Arnold (2006) minimum age models should be applied. However, these underestimate the quartz multi-grain ages by ~50% on average. The most prominent dose component from the Finite Mixture Model (Galbraith and Green, 1990) underestimates by ~15%. Simply taking the unweighted mean of the accepted single grain doses underestimates by ~5% on average. We conclude that for these samples the most accurate luminescence estimates of age are based on the light-summed signals derived from either single or multi-grain aliquots.

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An attempt to date potassium-rich feldspar that suffers partial bleaching and high fading rates

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The lower reaches of the river valleys in the western escarpment of the Peruvian Andes are characterized by fluvial terraces and alluvial fans at different elevations. Previous studies suggest that climate is an important factor for triggering the transition between aggradational and degradational phases of the fluvial systems (Steffen et al. 2009a). Three valleys between 10 and 12°S were sampled, with the idea to perform luminescence dating and establish a chronological framework for the formation of the terraces. The Peruvian sediments, however, show some challenging characteristics which complicate the application of luminescence dating. The quartz OSL signal is dominated by an unstable component which leads to a severe underestimation of the depositional age (Steffen et al. 2009b). IRSL dating of potassium-rich feldspar offers a promising alternative, although this signal may be affected by anomalous fading. Furthermore fluvial and alluvial sediments might also be affected by partial-bleaching.

A series of measurements has been conducted on the feldspar fraction of the samples. Single aliquot IRSL measurements revealed relatively broad distributions of D_e values (overdispersion 20-43%) and single grain IRSL measurements were carried out in an attempt to identify partially bleaching. Fading tests performed on single aliquots reveal high fading rates for the majority of the samples, with the average rate per sample ranging between 3 and 8% per decade. Additionally, fading tests were performed on single grains for a subset of samples. As high fading rates result in relatively large uncertainties on fading corrected ages, post IR-IRSL measurements were also performed on single aliquots and single grains in order to extract a signal that is less affected by fading. The ages obtained with the various methods will be compared and discussed. For two samples, single grain D_e measurements and fading tests were followed by electron microprobe analysis to relate feldspar chemistry to luminescence characteristics, and these results will also be presented.

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Performance of pulsed OSL stimulation for minimising feldspar OSL signal from quartz samples

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The use of pulsed OSL stimulation in order to remove feldspar OSL signal in quartz fractions has been suggested and tested by Denby et al. (2006) and Thomsen et al. (2008). These authors used either artificial or natural mixtures of quartz and feldspar grains, and reported that D_e values obtained from off-time OSL signal of mixed samples are indistinguishable from quartz D_e values from the same samples. Furthermore, Ankjærgaard et al. (2010) investigated quartz/feldspar signal ratios at various on- and off-times, and concluded that the ratio is optimised when equal on- and off-time pulses of 50 μs are used. However, quartz samples which have a feldspar contamination problem often have other difficult luminescence properties (e.g. dim OSL signal, no clear fast component, and significant sensitivity change due to heating). The performance of pulsed OSL for such quartz samples has not been investigated. I report the performance of pulsed OSL for ten sand-sized quartz samples from Tibet, Pamir, Egypt, and Italy, which show severe feldspar contamination in quartz OSL signals. The pulsed OSL D_e values for these quartz samples are typically ~30-50 % greater than the CW OSL D_e values due to anomalous fading of the feldspar OSL signal. The time-resolved natural and regenerated OSL signals for these samples are also presented in order to evaluate the purity of quartz OSL in their off-time OSL signals.

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Luminescence dating of scoria fall and lahar deposits from Somma-Vesvius, Italy

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Luminescence dating has been applied for the first time to scoria and lahar deposits from Somma-Vesvius, Italy, including two known-age scoria which were erupted at AD472 and 512 (or 536). Luminescence measurements were done after sieving the samples between 150 and 250 μm without any mineral separation. In order to find a stable luminescence signal which is less affected by anomalous fading, infrared stimulated luminescence (IRSL) signal at elevated temperature after bleaching with IR at 50°C (pIRIR) was tested at different preheat and elevated stimulation temperatures. The fading rates of both IRSL and pIRIR signals reduced dramatically with increasing preheat and pIRIR stimulation temperatures. A pIRIR signal simulated at 290°C after a preheat at 320°C (60 s) and an IR stimulation at 50°C (100 s) was selected to calculate equivalent doses (D_e). Dose rates were estimated based on an assumption that the luminescence signal originates from the most abundant leucite and/or minor sanidine phenocrysts. The ages of the two scoria samples agreed with the expected ages, whereas the ages of the lahar deposits indicate that they are associated with the AD1631 eruption.

Quantifying glacial erosion and relief evolution using luminescence thermochronometry (Granite Range, Alaska)

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Long-term exhumation and topographic evolution of mountain belts arise from complex coupling between tectonics, climate and surface processes. The recent development of luminescence thermochronometry (e.g., Herman et al., 2010; Guralnik et al., this volume) and its very low closure temperature (0-60°C) opens a new spatial and temporal "window" to study latest stages of rock exhumation, and address the nature of Quaternary topographic relief changes. We apply this new method in the Wrangell-St Elias National Park (Alaska), an alpine landscape that exhibits typical glacial features (U-shaped valleys, cirques, moraines). This setting provides an exceptional opportunity to study potential differences in relief evolution under a gradient of glacial forcing. We sampled four elevation profiles over an 80-km East-West transect across the Granite Range, where there is a consistent eastward increase in mean elevation, glacier activity, and topographic relief.

Feldspar separates from 15 bedrock surface samples were dated using the IR-50 protocol, and exhibit good internal reproducibility. Apparent ages vary from ~250 ka in the western part of the range, to younger ages of ~30 ka in the east, thus supporting the notion of amplified glacial activity on the east. Using a kinetic model to convert apparent ages into mean cooling histories, our work reveals spatially variable erosion rates during the late Quaternary, with preferential high-altitude erosion in the eastern part of the Granite Range and localized valley incision on its west. This represents the first quantification of relief limitation (so-called "glacial buzzsaw") in an active mountain range, and demonstrates the potential of luminescence thermochronometry in resolving topographic evolution and surface processes over 100-kyr timescales under high-frequency climate modulations (e.g., glacial-interglacial oscillations).

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Dating a lot of sand and one tree: testing the bootstrap likelihood Bayesian OSL approach with dendro-chronological age constraints

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The Minimum Age Model (MAM; Galbraith et al., 1999) has proven to be very powerful for statistical processing of equivalent-dose distributions from poorly bleached samples. However, results on stratigraphic sequences indicate that MAM uncertainty estimates are too optimistic. We have recently proposed a method to improve MAM uncertainty estimates (Cunningham & Wallinga, 2012). This bootstrap likelihood approach also allows the construction of probability density distributions of age, which can be used for Bayesian modelling (e.g. Oxcal) to combine data of different samples and/or data obtained using other methods.

Here we explore the possibilities of the bootstrap likelihood MAM approach combined with Bayesian analysis through a detailed investigation of a 2-m thick sequence of aeolian deposits. The sand at this site accumulated just next to a living tree, which managed to outgrow the sand deposition. OSL samples were heterogeneously bleached, likely due to a combination of the age of the source material, and short transport distances.

The bootstrap likelihood OSL approach applied to ten samples and dendrochronological information from buried segments of the tree are in good agreement. Both indicate that sand deposition occurred during two or three decades at the end of the 19th century. Combining results from the two independent methods allowed us to obtain a highly precise chronology. To our knowledge this is the first combination of OSL and dendrochronology on a single site.

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Dosimetry investigation using NaI(Tl) Gamma-ray spectrometer in various environments

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In the framework of the luminescence dating investigations carry out at the research laboratory of French museums, the external component of the annual dose-rate needed to calculate the age is usually based on arbitrary values, resulting uncertainty of the order of 15-20%. This is due to the fact that museum objects are usually out of context (exhibition or storage room). However sometimes we have to work on objects stored in-situ (historic monuments or archaeological sites). In these cases, it is possible to monitor the external dose rate received by the sample, thus reducing the uncertainty on the age to around 7%. Gamma scintillation spectrometry provides easy access to dose-rate, while providing information on the mean levels of radionuclides in the environment.

In this aim, we acquired, few years ago, a NaI (Tl) scintillation gamma-ray spectrometer. Three methods are used to evaluate the gamma dose rate (1) the total count (50 keV - 2780 keV) very close from the instant ratemeter value observed on the field.), (2) the global count above 500 keV (It is useful if artificial and natural radionuclides were monitored on the same spectrum. Artificial radioactivity appears at energies lower than 500 keV). and (3) the peaks count (K, U, Th).

In most cases, the measurement is made under conditions different from standard practice: insertion of the probe horizontally at 30 cm within a stratigraphic profile.

We report here some recent dosimetric studies conducted in various contexts: reconstruction dose for archaeological building by measuring both the dose from the surrounding soil and from the excavated walls; investigation of the radioactivity in our laboratory rooms; dosimetry study in the attic of churches to assess the gamma dose received by tiles; investigation of the dose rate in a river to date a shipwreck loading.