

## Thesis Abstracts

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**Author:** Gong Zhijun  
**Thesis Title:** Application of optical dating to late Quaternary uplift and thrust activity in the northern piedmont of the Tian Shan, China  
**Grade:** Ph.D.  
**Date:** August 2012  
**Supervisors:** Sheng-Hua Li  
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Tian Shan is one of the most important orogenic belts in central Asia. It has been reactivated as a result of the Cenozoic India-Eurasia collision. Dating of the late Cenozoic tectonic deformation of Tian Shan and its piedmonts is important for understanding the mountain building as well as evaluating seismic hazards in the region. This study is focused on the applications of optical dating to the late Quaternary uplift and thrust activity along Manas River, in the northern piedmont of the Tian Shan, China.

The sediments on river terraces were dated with optical dating. The elevations were measured with the kinematic global position system (GPS). The results suggest that two phases can be identified according to the significantly different river incision rates. One phase was from ~20 ka to ~4.8 ka, with a much slower incision rate of  $\sim 2.2 \pm 0.6$  mm/yr. The other phase was from ~4.8 ka to present, with a faster incision rate of  $\sim 13.5 \pm 0.6$  mm/yr. The accelerated incision rate of Manas River was mainly attributed to the tectonic forces, suggesting that the tectonic uplift was significantly intensified since ~4.8 ka in the northern piedmont of Tian Shan.

The study region has suffered from multiple thrust activities during the late Quaternary, which led to the intensively deformations of the river terraces. By studying the deformed terraces, I evaluated the timing of the past thrust activities as well as the vertical slip rate of the thrust faults. The results demonstrated that the thrust activity intensified during the late Holocene, as manifested by the more frequent thrust activities and higher vertical slip rates.

Both quartz and potassium feldspar can be as dosimeters for optical dating of sediments. However, quartz OSL is sometimes seriously impeded with problems such as very dim signals and insufficient bleaching problems. K-feldspar has attractive advantages over quartz, despite of problem of anomalous fading. K-feldspar was explored in this

study, by investigating the relationship between the infrared stimulated luminescence (IRSL) and blue light stimulated luminescence (BLSL) signals. For IRSL and BLSL at 60 °C, it was suggested that most of the IRSL could be bleached by blue light (BL), while the BLSL could only be partially bleached by infrared (IR) stimulation. Besides, the fast and medium components of BLSL were mainly associated with the IRSL. If IR stimulation temperature was raised from 60 to 200 °C, at least two portions of the IRSL signals at 200 °C were observed. One portion could be bleached by BL at 60 °C and the other portion was hardly bleached by BL at 60 °C. Dating of K-feldspar from the various signals provided cross-checking for the reliability of quartz OSL for dating sedimentary samples.

**Author:** Julie A. Durcan  
**Thesis Title:** Luminescence dating of sediments in Punjab, Pakistan: implications for the collapse of the Harappan Civilisation  
**Grade:** Ph.D.  
**Date:** December 2012  
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This study presents the first application of optically stimulated luminescence (OSL) dating in the lowlands of Pakistan. More specifically, the Pakistani section of the Ghaggar-Hakra palaeochannel is dated for the first time, having been the subject of research for over a century. The Ghaggar-Hakra is associated with a dense concentration of Mature and Late Harappan archaeological sites. The Mature Harappan are hypothesised to have collapsed at ~3.9 ka, and it has been hypothesised that changing fluvial activity and climatic variability were key factors in the demise of this civilisation. This thesis aims to use OSL dating to develop a chronology of fluvial activity for the palaeochannel and to establish whether there is a temporal link between changing fluvial activity and climatic variability. The chronology is also compared with records of archaeological change to ascertain whether changing

fluvial activity contributed to the Mature Harappan collapse.

The majority of work presented in this thesis is concerned with the development of an accurate geochronological framework using OSL dating. The fast ratio is developed as a means for assessing the dominance of the fast component in the initial part of a quartz OSL signal and range-finder OSL dating is developed as a protocol for rapid age estimation using the quartz OSL signal, providing age estimates with uncertainties within 20%. Equivalent dose calculation using statistical models is discussed and the extent of incomplete bleaching in the dataset is considered. OSL ages dating predominantly from the Holocene are presented.

Based on the OSL ages calculated, strengthened fluvial activity in the Ghaggar-Hakra palaeochannel during the early and mid-Holocene is observed. Flow recession up-channel during the mid-Holocene is inferred, and a hiatus in fluvial deposition in the channel is observed between 4.5 and 1.4 ka. Changes in fluvial activity in the Ghaggar-Hakra are driven by the intensity of the Asian Monsoon, which fluctuates during the Holocene. Changing fluvial activity coincides with documented archaeological change and it is concluded that changing fluvial activity driven by climate was a significant factor in the collapse of the Mature Harappan at ~3.9 ka.

**Author:** Alicia Medialdea  
**Thesis Title:** Towards the reconstruction of flood histories: Luminescence dating of palaeoflood deposits  
**Grade:** Ph.D.  
**Date:** February 2013  
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The accurate dating of palaeoflood deposits plays a key role in the understanding of river flooding events, which are one of the main natural hazards related to climate, causing severe damage on mankind's life. The latest developments in the measuring and data analyses applied to optically stimulated luminescence dating (OSL) have made this technique highly reliable to assess chronologies for Quaternary

processes. But in some cases OSL can be hampered and the achievement of accurate ages becomes a challenge. This is the case of young flash-flood deposits which are likely to be affected by incomplete bleaching and in which any extrinsic factor could lead to a dramatic misestimate of the burial age.

Flood sediments from four rivers of the Iberian Peninsula (Guadalentín, Rambla de la Viuda, Huebra and Duero) have been sampled, covering a wide variety of environments for this thesis. A sequence of eight modern (40-1000 years) flash-flood deposits, potentially affected by incomplete bleaching, with available age control from historical records and radiocarbon ages has been used as reference values. Results from measurement of small (~30 grains) multi-grain aliquots have been compared to those derived from single grains. Burial ages have been estimated by using descriptive and robust statistics, the Central Age Model (CAM), Minimum Age Model (MAM) and Internal-External Consistency Criteria (IEU). A data transformation has been proposed in order to apply CAM and MAM models to dose distributions containing zero and negative values. All approaches have been applied to both, multi-grain and single grain doses.

The effect of the assumed over-dispersion on the burial dose estimation has been studied in detail finding a moderate effect when applying IEU approach and a very strong effect when using MAM model. Over-dispersion has been assigned based on dose recovery experiments measured on bleached/gamma dosed samples.

Comparison of the different OSL burial dose estimates with the independent age control indicates that best ages are achieved when using IEU approach. Consistent results are found for small multi-grain aliquots and single grains, showing that small (~30 grains) multi-grain aliquots in combination with minimum age models (i.e. IEU, MAM) are suitable for age estimation even in samples with high percentage (up to of incompletely bleached grains). Achieved conclusions have been applied to date the samples from the remaining three rivers. In all cases the estimated ages are consistent with the stratigraphy.

**Author:** Yiwei Chen  
**Thesis Title:** Optical dating investigation into the slip rate of Altyn Tagh Fault and evolution of Zhari Namco, Tibetan Plateau  
**Grade:** Ph.D.  
**Date:** March 2013  
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New applications of the optically stimulated luminescence (OSL) dating were carried out with the aim of understanding late Quaternary activities for the Tibetan Plateau. This included studying the slip rate of the Altyn Tagh Fault, northeast Tibetan Plateau, and revealing the environmental changes derived from large inland lake's evolution, central south Tibet.

Two deflected streams across the Altyn Tagh Fault close to Aksay (39°24.572'N, 94°16.012'E) were investigated. Geomorphological analysis suggests that loess covering deflected stream banks has recorded past faulting events. A conceptual model is proposed illustrating the relationship. OSL dating of sixteen loess samples at both streams support the model, suggesting the loess is deposited episodically after fault strikes and subsequent channel wall refreshment. The age and offset indicate a slip rate of  $11 \pm 2$  mm/yr for this part of the Altyn Tagh Fault.

Another river section near Aksay was also investigated for the slip rate information. Two risers between three terraces are clearly offset; OSL dating of loess covering terrace surfaces yielded terrace ages. Using the upper-terrace age to represent riser displacement duration, the rate is estimated to be  $12 \pm 1$  mm/yr. The result suggests that using upper terrace is more suitable in this region. Notably, though, the slow rate is at odds with proposals that assume high-speed extrusion (~23 mm/year) of the Tibetan Plateau being accommodated by the Altyn Tagh Fault.

Palaeo-shorelines around the third largest lake in Tibet, Zhari Namco, were for the first time systematically investigated using OSL dating. Twenty-two sediment samples from eleven shorelines indicate that the water level has dropped ~128 m and the lake has undergone stepwise shrinkage since 8.2 ka. Digital elevation model calculation indicates the lake has shrunk from 4605 km<sup>2</sup> in size at 8.2 ka to 996 km<sup>2</sup> at present, which is equivalent to ~300 km<sup>3</sup> of water. This implies a significant reduction in precipitation over the past 8.2 ka, a result of weakening Indian Monsoon or a shift of monsoon circulation path. The result is consistent with other

lake-core, ice-core climate proxies and solar insolation changes, implying the dominance of a weakening Indian Monsoon over central Tibet in the Holocene. Using the elevation of the highest shoreline of the four largest lakes in Tibet, the early Holocene Pan-lake hypothesis is proposed for the central Tibet.

In addition to these applications of OSL dating, technical studies on sensitivity changes and residual doses have been carried out for potassium rich feldspar (K-feldspar). Recent development of infrared stimulated luminescence (IRSL) signals from K-feldspar has shown great potential for extending the datable range for OSL dating. Sensitivity changes and residual doses of post-IR IRSL and multi-elevated - temperature post-IR IRSL protocols for K-feldspar were studied. A sensitivity decrease is observed after adopting a high temperature IRSL. IRSL signals stimulated at high temperature are found to contain large residual doses. The residual dose rises with stimulation time, suggesting that the initial part of IRSL signals contains more easy-to-bleach signals comparing with the later part.

**Author:** Carly Leighton  
**Thesis Title:** Desert dune system response to Late Quaternary environmental change in the northeastern Rub' al Khali: Advances in the application of optically stimulated luminescence datasets  
**Grade:** Ph.D.  
**Date:** November 2013  
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The application of optically stimulated luminescence (OSL) dating to desert sand dunes has allowed accumulation histories to be used as tools to infer past environmental change. In response to issues facing the interpretation of these records, two research questions are addressed in this thesis. (i) Are dune chronologies representative of dune stratigraphies? And (ii) how can we most appropriately interpret dune chronologies as records of Quaternary environmental conditions?

Five dune profiles were sampled for OSL dating at two sites in the northeastern Rub' al Khali in the southern Arabian Peninsula. The visible stratigraphy

was used to guide sampling for three of the profiles and the effectiveness of this approach is assessed. A key finding is that bounding surfaces are not always identifiable as chronological hiatuses by OSL dating, given the level of precision that can be achieved. Using hierarchical relationships visible in two-dimensional exposures is therefore not guaranteed to identify the depositional units necessary to reconstruct dune histories.

Comparison of the depositional records from three sampled profiles shows that there is significant variability in chronologies at both the dune and dunefield scales. In light of these findings, the use of 'range-finder' OSL dating was investigated as a method of increasing sample throughput in the laboratory. It is concluded that the use of partially prepared samples and shortened measurement techniques can be used to rapidly assess the chronological context of samples and target those units most useful in constructing dune profiles.

A new method of presenting dunefield OSL datasets as net accumulation rates, incorporating accumulation thickness rather than relying on the frequency of ages, is presented. Within the last 30 ka, regional accumulation and preservation occurred at ~30-26, 22.5-18, 16-9, 6-2.7, 2.1-1.6, 1.1 and 0.7 ka. In conjunction with numerical model results and a review of other palaeoenvironmental archives, the regional aeolian record is interpreted as a response to changing forcing factors. High rates of net accumulation between ~16-9 ka are attributed to coeval increases in sediment supply and transport capacity. A hiatus in accumulation between ~9-6 ka is interpreted as a result of reduced sediment availability due to high moisture levels. The importance of both external forcing factors and local controls on dune accumulation processes is recognised, and therefore the importance of sampling at multiple locations to distinguish these factors is emphasised.