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EDITED AND REVIEWED BY
János Kovács,
University of Pécs, Hungary

*CORRESPONDENCE
Hui Zhao,
hzhao@lzb.ac.cn

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Editorial: Trapped charge dating and its application in geomorphological, geological and archaeological studies in East Asia

Hui Zhao^{1*}, Hao Long², Yuxin Fan³ and Bo Li⁴

¹Key Laboratory of Desert and Desertification, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Science, Lanzhou, China, ²State Key Laboratory of Lake Science and Environment, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing, China, ³School of Earth Sciences and Key Laboratory of Mineral Resources in Western China (Gansu Province), Lanzhou University, Lanzhou, China, ⁴Centre for Archaeological Science, School of Earth, Atmospheric and Life Sciences, University of Wollongong, Wollongong, NSW, Australia

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Editorial on the Research Topic

[Trapped charge dating and its application in geomorphological, geological and archaeological studies in East Asia](#)

Trapped charge dating refers to two main techniques, luminescence (OSL/IRSL) dating and electron spin resonance (ESR) dating, and both based on the time-dependent storage of energy from natural radioactivity in crystal materials. Luminescence dating is commonly used to date the last time since quartz or feldspar grains in rocks or sediments were exposed to sunlight or heating, as well as the exposure age of rock surface. ESR is mainly applied for dating biogenic materials such as fossil tooth, but can also be used to date quartz. Given its wide dating range (from decades up to more than one million years) and availability of materials (quartz and feldspars, more than 70% of Earth's crust), trapped charge dating has become one of the most important dating tools for studying Earth and its inhabitants during the Quaternary. The techniques have been successfully applied to various geological context and geomorphological processes, including aeolian, fluvial, alluvial and lacustrine deposits which recorded paleoclimatic and paleoenvironmental changes, provenance of sediments, tectonic activities, accumulation and erosion; and human migration etc.

This Research Topic focuses on new advances in trapped charge dating and its application to various deposit contexts. This collection includes 14 papers covering the studies of the characteristic of the luminescence signals; reconstruction of fluvial geomorphological process, aeolian processes in deserts and sandy lands, and human migration history in East Asia.

Six papers in this Research Topic focused on the applications of the luminescence dating to the paleoshorelines or the fluvial terraces to explore the lake level variability, and the geomorphological process etc. [Wu et al.](#) studied the late Quaternary lake shrinkage of Dagze Co in central Tibetan Plateau. Based on OSL dating and differential GPS measurement, it is found that a high lake level (+55 m) occurred at 9.1–9.6 ka followed by two abrupt drops (9–8 ka and after 5 ka). It was proposed that the long-term decreasing trend of Asian monsoon precipitation could be the main reason for this major drop of lake level. Several studies have documented recent rapid incision events in northeastern Tibet that are probably linked to global climate change. However, it is unclear whether the incision process occurs in vast areas to upper reaches or is restricted in lower reach of the rivers. [Cao et al.](#) dated the Quaternary fluvial terraces of the rivers in Northeastern Tibet. They suggest that the adjustment of the climate-induced longitudinal river profile is limited to the downstream reach. [Tamura et al.](#) applied K-feldspar pIRIR dating to identify the sedimentary sequences in an uplifted coast since the Middle Pleistocene, eastern Japan. This study provides a valuable and comprehensive case study of feldspar pIRIR dating application to the coastal stratigraphy and shows how useful the resultant chronology is for defining sedimentary sequence formed in response to glacial-interglacial sea-level oscillations. The eastern margin of the Tibetan Plateau experienced extensive tectonic activities in the form of earthquakes and landslides. To further understand the timing of the activities, [Zhang et al.](#) selected the strath terraces of the Minjiang River in the region for luminescence dating. Seven strath terraces (T1 to T7) were recognized, and 16 sedimentary samples were collected from the terraces. Quartz OSL dating results show that the terraces T1–T6 formed during the intervals of 13–63 ka. [Liu et al.](#) applied the quartz OSL dating to the alluvial fan deposits from the Helan Mountain, North China. They found that the dating results were affected by the aliquot-size with different age model. This research makes the dose dependency of aliquot sizes and age models more definite and shows a possibility of dating paleo-alluvial deposits to establish a chronological framework. [Li et al.](#) applied K-feldspar pIRIR₁₅₀ signals to date the Late Pleistocene sediments in the NW Khangai Mountains (Mongolia) using a standardized dose response curves (sDRC) approach. The sDRCs and DRC of individual samples yield consistent age, supporting that the sDRCs are applicable for luminescence dating with improvement of measurement efficiency. However, a comparison between the radiocarbon dates, the fading corrected pIRIR₁₅₀ and IR₅₀ ages may be overestimated due to fading over-correction.

Three articles in the Research Topic applied the ESR dating or luminescence dating to the archeological sites to obtain the history of the human migration in the East Asia. [Han et al.](#) obtained the chronology of early human settlement in Three

Gorges Region (TGR), China, by using the ESR and Uranium-series dating methods. TGR is a probable migration corridor for hominins and other mammals between South and North China. Seven important Early and Middle Pleistocene hominin settlement sites were studied, and hominins were proposed to be settled in TGR probably from ~2.5–2.2 Ma at the Longgupo site, and to the Yumidong site at ~274–14 ka and likely to spread to other parts of East Asia during this time period. [Guo et al.](#) re-dated the Zhuwobu Paleolithic site, a part of the “generalized” Nihewan Basin, in the Huailai basin, North China, using the MET-pIRIR procedure on both single and multiple aliquots of K-feldspars. The results suggest that the cultural layer at this site was deposited about 280 ± 13 ka ago, ~220 ka younger than the previous ESR age (504 ± 76 ka) which might be overestimated due to poor bleaching before burial. In contrast, the ESR age of 346 ± 32 ka for the sample collected from same cultural-layer might be more reliable due to higher-quality bleaching before burial. Pottery and burnt clay are the most abundant dating material available in neolithic archaeological sites. [Wang et al.](#) reported the OSL and TL dating application to heated quartz grains extracted from pottery and burnt clay excavated from the archaeological site of Lingjiatan, China. The study provided new insights on the luminescence characteristics of heated quartz, including sensitivity, components, fast ratio, thermal stability, recuperation, etc., and explored their effects on luminescence ages. Two types of quartz signals were distinguished in terms of their component and sensitivity characteristics. They highlighted that a modified measurement procedure should be used for the type of samples that decay slowly to obtain accurate optical ages. Compared with ¹⁴C dates from charcoal chips extracted from the burnt clay, OSL dating provides a robust method to obtain the accurate time since the last archaeological heating event.

Methodological studies of luminescence characteristics of the OSL/IRSL signals are important for the application of the optical dating. Five articles in this Research Topic focus on the sensitivity and bleaching condition of OSL or the IRSL signals. [Zhang et al.](#) studied the bleaching limits of IRSL signals at various stimulation temperatures and their potential inference of the pre-burial light exposure duration. They conducted comprehensive bleaching experiments of IRSL and pIRIR signals, demonstrating that a non-bleachable component exists in the IR (and possibly pIRIR) signals, and positively correlated with preheat/stimulation temperature. It is noteworthy that the relative residual signal level is consistent between the IR₅₀ and pIRIR signals for the same preheat temperature. Subsequently, authors proposed a novel approach to explore the pre-burial light exposure history of sediment utilizing multiple feldspar pIRIR signals. [Mo et al.](#) focused their study on the bleaching degree of multi-grain coarse quartz OSL signal of near-surface aeolian sediments collected around the margin of the Tengger Desert. In this

study, methods of empirical investigation and numerical validation were applied to assess the bleaching degree of the coarse-grain fraction of near-surface aeolian sediments. The results reveal that the limitation of traditional methods in the identification of heterogeneous bleaching for aeolian sediments measured from multi-grain aliquots. It concludes that the wind-driven erosion/reworking of the stationary near-surface sediments and/or the absence of severe aggregation leads to the fully bleaching of the investigated multi-grain samples. The quartz luminescence sensitivity (QLS) has been used as one proxy in the provenance investigation of Quaternary sediments. Liu et al. studied the luminescence sensitivity of quartz grains in five typical loess sequences obtained from the eastern Tibetan Plateau. Their results show significant spatiotemporal variations in the quartz luminescence sensitivity at different locations, indicating that the dust sources have played an important role in the variation of the QLS and the QLS can be used for tracing the loess in the Tibetan Plateau. However, the study of eight samples from Permian biotite monzogranite in Cao et al. indicates further research is required to apply the thermal activation curves in the study of provenance, though the degree of chemical weathering does not correspond with the QLS values of samples that have undergone varying degrees of *in situ* weathering and that quartz from the same source with varying degrees of *in situ* chemical weathering has a constant response to irradiation-bleaching cycles. Rui et al. tested the reliability of using the continental standardized growth curves (SGCs) by using coarse quartz grains from Lake Woods in Northern Australia. They applied full SAR procedure to individual quartz grains, and built regional SGCs for Lake Woods. With the obtained data, they calculated SAR D_e , regional SGC D_e and continental SGC D_e for the studied samples, and found that D_e values obtained by continental SGCs are consistent with D_e values obtained by regional SGCs and by the SAR procedure. It was proposed that the continental SGC can be successfully applied to coarse quartz grains from Lake Woods, and large instrument time can be saved by using this method.

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