Luminescence dating –what is it, what can it do, and why is it important?

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The Earth’ s surface is an archive of the history of our species and of our environment but to read and interpret the information recorded in this archive, we must have a means of knowing when the various records were preserved, and so when the events actually happened. Luminescence dating is an important and widely-applicable chronological tool used to date these records. The technique is not new, but recent developments have led to an explosion in applications, so that today it is one of the three most widely used methods in the geo- and archaeo-chronology of the last 500,000 years. This talk outlines the principles of the method, and discusses the advantages and limitations of the most widely-used form, optically stimulated luminescence (OSL) dating. Evidence for the precision and accuracy of the method is presented. The importance of the technique to studies of human evolution and migration, and to our understanding of past climate change is then illustrated using studies ranging in scale and time from the recent bioturbation of mudflats to late Quaternary ice advances in Eurasia. Finally, exciting new developments in rock surface dating are summarised.
It is concluded that OSL dating in its various forms is the most widely applicable dating tool available to earth scientists and archaeologists. It has grown from being relatively minor and unimportant to become one of the three pillars supporting modern archeo- and geo-chronology, and despite nearly 60 years of development, new signals, new techniques and new applications are constantly appearing. It continues to be a very exciting field in which to work.

Keywords: OSL dating, geochronology, quartz feldspar, rock surface dating

High-resolution OSL dating of cut-and-fill beach deposits for assessing beach erosion history in Bengello Beach at Moruya, SE Australia

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Quartz optically-stimulated luminescence (OSL) dating can determine the depositional age of very recent (tens of years) sediments in optimal environments such as beach and dune field. Very rarely, extreme storms can cause significant beach retreat and thus estimating their extent and frequency is critical for coastal property. However, modern beach observation is generally too short for the infrequent nature of such events. Prograded beach deposits resulting from long-term beach erosion and deposition, if dated continuously from the recent past to present, potentially provide a record of the beach erosion history. Here we show a geological assessment of extreme beach retreat in Bengello Beach at Moruya, southeastern Australia, based on high-resolution quartz OSL dating coupled with Bayesian modeling, and ground-penetrating radar (GPR) surveys. Beach monitoring since 1972 reveals that the Bengello Beach has shown a typical cut-and-fill pattern, in which the beach retreats several tens of meters in relation to storm events and immediately recovers within the following few years. A storm event caused extreme beach retreat of up to 50 m in 1974. Since then, no storm event has been associated with retreat exceeding 30 m. It has thus been argued that the 1974 erosion was an event that happens once in 50–100 years. The beach monitoring defines a beach profile envelope, and indicates that the upper foreshore deposits can only be preserved as stratigraphic records during rapid beach recovery following a large retreat deeper than the envelope. Thus, ages of the preserved upper foreshore deposits are considered as roughly corresponding to timings of large-scale retreat. Sediment samples for OSL dating were collected from the subsurface of the beach-ridge plain behind Bengello Beach. Sample sites were located at 5–10 m intervals along a shore-normal transect extending from the modern foredune to 120 m inland. The GPR profile confirmed all the samples were taken from prograded upper foreshore deposits. The most landward, oldest sample was dated as 510 yr, indicating that the net seaward accretion rate of beach-ridge plain is 0.24 m/yr, concordant with the average rate since the mid Holocene. Other OSL ages show four events of beach retreat at 350, 180, 130, 90 yr, and also reflect the presence of the beach scarp resulting from the 1974 event. Assuming a constant rate of beach accretion of 0.24 m/yr, the retreat of the four events is estimated as 45–55 m, respectively, similar to that in 1974. A 40-m interval of beach deposits following the 350 yr event, shows four identical OSL ages ranging from 350 to 330 yr, and is associated with a 150 yr gap before the unit immediately seawards. This suggests beach retreat was relatively modest during 330–180 yr. At Bengello Beach, extreme beach retreat, including that in 1974, happened at least five times over the last 350 years at a variable recurrence interval of 50–150 years.

Keywords: coast, chronology, sedimentology, Quaternary science, luminscence dating

Luminescence characteristics and IRSL-chronology of extreme-wave event deposits recorded at the Shirasuka lowlands, Japan

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The location of Japan at the Pacific-Philippine-Eurasian subduction zones makes it vulnerable to earthquakes and subsequent tsunamis. Furthermore tropical cyclones cause destructive storm surges. Both natural hazards may generate extreme-wave events, which are a major threat for coastal communities.
The Shirasuka lowlands, sandwiched between a Mid-Pleistocene terrace and a coastal dune, record evidence for numerous extreme-wave events. Located along an important historical trade route, their impact history is well documented in written sources and a radiocarbon chronology has been developed for seven extreme-wave event deposits previously identified in this area (Fujiwara et al., 2006; Komatsubara et al., 2008). Therefore, this study area provides an excellent opportunity for testing the applicability of OSL dating to young (< 800 years) coastal, potentially incompletely bleached extreme-wave event deposits.
Quartz is preferred for dating such sediments, due to its faster rate of signal resetting. However, OSL measurements failed due to low signal intensities, absence of a fast component, and sensitivity to IR stimulation. Consequently, feldspar was used instead. The $IRSL_{50}$ signal has high signal intensities and resets quickly. However, thermal transfer affects these young feldspars. To minimise this effect and thus reduce recuperation, a second optical stimulation at 130 ˚C was included in Lx and Tx cycles of the $IRSL_{50}$ protocol.
Final dating was performed on single-grains of feldspars to (i) lower residuals, and (ii) account for potentially incomplete bleaching.
The resulting ages cover the known historical record of the extreme-wave events of the last 800 years at Shirasuka. Sand sheets can be correlated with tsunamis in AD 1361, 1498, 1605 and 1707. A poorly bleached equivalent dose distribution of the uppermost sand sheet hints at a different transport mechanism. The IRSL age range suggests a correlation with the Tonankai earthquake in AD 1944. Since the subsequent tsunami did not inundate the study area, a terrace slope failure due to intense shaking, is suggested for this sand sheet.

Fujiwara, O, Komatsubara J, Takada, K, Shishikura, M, Kamataki, T (2006), Journal of Geography 115: 569-581 (in Japanese).
Komatsubara, J, Fujiwara, O, Takada, K, Sawai, Y, Aung, TT, Kamataki, T (2008), Sedimentology 55: 1703-1716.

Keywords: feldspar, single grain, tsunami deposits, storm surge deposits

Constraining the timing of the caldera outburst floods from Aso volcano

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The bouldery volcaniclastic apron sediment (Takuma gravel bed) west of Aso volcano and the overlying tephric loess were studied by Tsukamoto et al (2013) and a preliminary luminescence age constraint of 72-89 ka for the timing of the caldera outburst flood event, which built the volcaniclastic apron, has been reported. In this study we collected additional samples to further constrain the timing of the caldera outburst flood event. Samples were also taken from the Aso-4 ignimbrite, Hotakubo gravel bed consisting of the lower volcaniclasic apron along the Shirakawa River, and the tephric loess deposited above the gravel bed. The luminescence measurements of the tephric loess samples were performed using two post-IR IRSL (pIRIR) protocols with the pIRIR stimulations at 225˚C and 290˚C. The two pIRIR signals gave consistent ages and the result indicates that the gigantic caldera outburst flood event probably occurred shortly after the Aso-4 eruption, ~86 ka, and the another bouldery Hotakubo gravel bed, which is of cut terrace deposits derived from Takuma gravel bed or of other possible flood event occurred at ~47 ka. The ages will be further compared with the pIRIR ages from the gravel beds themselves. Interestingly, the Aso-4 ignimbrite using the pIRIR signal at 225˚C was dated to a much younger age (~40 ka) than the reported eruption age at ~87 ka (Aoki, 2008). This probably indicates that a very long time was needed for the sampled Aso-4 ignimbrite until the temperature reached to the effective closure temperature of the signal (~60-80˚C, King et al., 2016).

References

Aoki, K. 2008. Revised age and distribution of ca. 87 ka Aso-4 tephra based on new evidence from the northwest Pacific Ocean. Quaternary International, 178, 100-118.

Tsukamoto, S., Kataoka, K.S., Miyabuchi, Y. 2013. Luminescence dating of volcanogenic outburst flood sediments from Aso volcano and tephric loess deposits, southwest Japan. Geochronometria, 40, 294-303.

King, G.E., Herman, F., Lambert, R., Valla, P.G., Guralnik, B. 2016. Multi-OSL-thermochronometry of feldspar. Quaternary Geochronology, 33, 76-87.

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