

Defining the upper age limit of luminescence dating: A case study using long lacustrine records from Chew Bahir, Ethiopia

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Optically stimulated luminescence (OSL) dating is a family of numerical chronometric techniques applied to quartz or feldspar mineral grains to assess the time since these grains were last exposed to sunlight (i.e. deposited), based on the amount of energy they absorbed from ambient radiation during burial. The maximum limit of any OSL dating technique is not defined by a fixed upper age limit, but instead by the maximum radiation dose the sample can accurately record before the OSL signal saturates. The challenge is to assess this upper limit of accurate age determination without necessitating comparison to independent age control. Laboratory saturation of OSL signals can be observed using a dose response curve (DRC) plotting OSL signal intensity against absorbed laboratory radiation dose. When a DRC is fitted with a single saturating exponential, one of the equation's parameters can be used to define a pragmatic upper limit beyond which uncertainties become large and asymmetric (Wintle and Murray, 2006). However, many sub-samples demonstrate DRCs that are best defined by double saturating exponential equations, which cannot be used to define this upper limit.

To investigate the reliability of luminescence ages approaching saturation, Chapot et al. (2012) developed the Natural DRC concept, which uses expected ages derived from independent age control, combined with sample-specific measurements of ambient radioactivity, to calculate expected doses of absorbed radiation during burial. Natural OSL signal intensity is then plotted against these expected doses and compared to laboratory-generated DRCs. Using this approach, discrepancies between natural and laboratory DRCs have been observed for the same mineral material as natural OSL signal intensities saturate at absorbed radiation doses lower than the pragmatic upper limit defined by laboratory DRCs, leading to increasing age underestimation with depth without a metric for questioning the age reliability.

The present study explores a means of defining the upper limit for reliable luminescence ages for sedimentary records without an established chronologic framework, using a long (~280m; Cohen et al., 2016) lacustrine record from Chew Bahir, Ethiopia, drilled as part of the Hominin Sites and Paleolakes Drilling Project (HSPDP) of the International Continental Scientific Drilling Programme (ICDP) and CRC806 "Our way to Europe". Natural saturation of OSL signals is explored by plotting natural signal intensity against depth, creating a pseudo-Natural DRC that can be compared to laboratory DRCs. Unlike the homogenous deposits of the Chinese Loess Plateau where the Natural DRC concept was developed, the ~280m composite core from Chew Bahir shows significant variation in lithology enabling investigation of the effects of sample to sample variability on Natural DRC construction, and facilitating comparison between signals from fine-quartz, fine-polymineral, and coarse-potassium feldspar grains. This work demonstrates how the concepts of Natural DRCs can be used to define the upper dating limit of sample suites without independent age control, providing valuable information for long sedimentary sequences such as the lacustrine deposits from Chew Bahir.

Chapot M.S., et al. (2012), *Radiation Measurements* 47: 1045-1052.

Cohen A, et al. (2016), *Scientific Drilling* 21: 1-16.

Wintle, A.G., Murray, A.S. (2006) *Radiation Measurements* 41: 369-391.