Thesis Abstracts

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Thesis Title: Investigations of alternate and innovative ways of performing luminescence dating in an attempt to extend the age range
Grade: PhD
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At the present stage in its development, optically stimulated luminescence (OSL) using quartz has been demonstrated to provide accurate ages from ~ 5 years (Ballarini et al., 2003) to ~ 125 ka (Murray and Olley, 2002). A handful of dates from known age sediments have been published beyond 125ka. However, most of these were the consequence of a low environmental dose rate (the luminescence age is calculated by dividing dose by dose rate) rather than because of an unusually large accumulated dose. This project concerns investigating the possibility of extending the age range of luminescence dating. More precisely, it is about finding and/or validating a different measurement approach that will enable us to measure a much larger equivalent dose.

The primary objective of this project consists of investigating the reliability of alternate ways of measuring the luminescence from quartz and K-feldspar minerals. Part I discuss a novel approach for measuring the luminescence from quartz (isothermal thermoluminescence). It showed a potentially higher saturation growth curve, which could enable the measurements of older sediments. Sensitivity changes, between the measurement of the natural and regenerated luminescence prevented accurate dating. Despite intensive investigations into material from a variety of sources, it has proved impossible to develop a reliable measurement procedure.

Efforts were concentrated on the luminescence from feldspars during the second part of the thesis and those are presented in Part II. Feldspars have long been known to have an extended dose response, but athermal fading of the dosimetry signal has prevented their use. A novel approach was investigated, namely time-resolved luminescence, which potentially holds a means to circumvent athermal fading. Investigation showed it was not the case, however.

Methods have been proposed to correct for this fading, but with limited testing. The application of such correction methods to known age samples with doses of up to ~ 160 Gy shows promising results. It is important that evaluation of fading rates be as precise and accurate as possible, because of the problem of multiplication of errors. A reduction of the scatter encountered in fading measurements was obtained by using helium instead of nitrogen as the atmosphere in our measurement system. The gas improves thermal contact and makes thermal pretreatment more reproducible, and thus reduces variability in the feldspar luminescence signal.

The potential of sodium feldspars (Albite) was briefly explored in extending the age range. Albite has very similar luminescence properties as potassium feldspars, the latter being the common mineral used in dating. Albite has the advantage of having a simpler dosimetry, compared to potassium feldspars, due to the absence of internal K, thus extending the age range and reducing uncertainties associated with the determination of internal K.

Application to dating burial ages from sediments was achieved through collaborative efforts with visitors coming to the Nordic Laboratory for Luminescence Dating. Most projects contained at least one reliable independent age to ascertain the validity of our dating procedure.

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Thesis Title: Application of luminescence dating to the study of archaic age anthropogenic mounds from the lower Mississippi River Valley
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Intense solar bleaching of minerals in active surface soils is a widespread phenomenon. The process of soil turbation distributes soil-bleached grains to some depth. These grains have been viewed variously as a source of contamination in optically stimulated luminescence (OSL) dating of deposits and as a source for chronological information about the soil itself. This work investigates the possibility of applying OSL dating to buried soils using coarse-grained quartz. It focuses on buried soils with reliable

independent age assessments from earthen mounds of archaeological import.

Special attention has been given to developing a soil genesis model for the distribution of solar-bleached grains through the depth of a soil horizon. In this model the soil surface is viewed as a bleaching platform that is continuously stressed and loaded by subsurface turbation mechanisms creating surface relief. Subaerial impact- and transport-forces, such as rain, wind and floral growth, impact surface relief causing disaggregation and single-grain dispersion. This surface "bleaching zone" offers frequent and thorough presentation of mineral grains to solar radiation. In this model, soil turbation distributes bleached grains through the soil horizon and brings unbleached grains to the surface.

Absorbed doses in single-aliquots and single-grains of quartz are determined using the single-aliquot regenerative dose (SAR) protocol. Modern active soils similar in composition and environment to paleosols at depth are analyzed as controls. The concentration of zero-age grains decreases with depth. Minimum age analysis of grains from within 5 cm of the surface results in near-zero ages.

Dose depth profiles were studied from 35 cm long cores through 9 buried paleosols from the interior of prehistoric earthen mounds. The position of the buried soil surface within the core was determined from field measurements and confirmed by extensive laboratory soil analysis. Dose distributions with paleosol depth conform to our model and meet expectations of aged buried surfaces. OSL minimum ages from these buried soils demonstrate good agreement with previously published ages. It is concluded that many soils are competent mechanisms for thorough exposure of near surface minerals to solar radiation.