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Thesis Abstracts

Author: Christina Ankjærgaard
Thesis Title: Understanding optically stimulated charge movement in quartz and feldspar using time-resolved measurements
Grade: Ph.D.
Date: May 2010
Supervisors: Mayank Jain (Risø DTU), Stig Steenstrup (University of Copenhagen)
Address: Radiation Research Division, Risø Natural Laboratory for Sustainable Energy, Technical University of Denmark (DTU)

Optically stimulated luminescence (OSL) from quartz and feldspar is widely used in luminescence dating and other forms of retrospective dosimetry. In order to develop new techniques to extend the general applicability of the dating technique it is important to understand the processes of luminescence generation in these minerals. OSL is a multi-step process involving charge excitation, transport, and recombination; using time-resolved OSL (TR-OSL) one has the possibility to directly examine the role of charge transport and recombination in luminescence emission.

The thesis is a compilation of 9 published articles, an introduction, and a summary chapter. It first delves into three main methodological developments, namely, (i) research and development of the equipment for TR-OSL measurements, (ii) finding the best method for multiple-exponential analysis of a TR-OSL curve, and (iii) optimisation of the pulsing configuration for the best separation of quartz OSL from a mixed quartz-feldspar sample. It then proceeds to study the different charge transport mechanisms subsequent to an optical stimulation pulse in quartz and feldspars over time scales covering 9 orders of magnitude (tens of nanoseconds to tens of seconds).

The results obtained for quartz conclude that the main lifetime component in quartz represents an excited state lifetime of the recombination centre, and the more slowly decaying components on the millisecond to seconds time scale arise from charge recycling through shallow traps.

Feldspars are studied using IR, green and blue stimulations and a combination of TR-OSL and time-resolved exo-electron (TR-OSE) emission

techniques. It is shown that irrespective of composition, the TR-OSL shape of feldspars are very similar to each other, and that the lifetime of the excited state of the recombination centre is not important on the time scales of our measurements. The measurements give insights into the relative roles of an IR excited state (IR resonance), band tail states and the conduction band during charge transport in feldspars. Phonon assisted transport and tunnelling from the band tail states are characterised for the first time. It is shown that the band tail route favours production of a signal with a lower fading rate. Based on these results a comprehensive model of feldspar luminescence is developed, and different methods are proposed to deal with the long standing problem of anomalous fading.

This thesis is available as a PDF on the Ancient TL web site www.aber.ac.uk/ancient-tl

Author : Dorte Pflanz
Thesis Title: Coastal Development in Eastern Kamchatka – results from OSL Dating, Remote Sensing and Fieldwork
Grade: Ph.D.
Date: November 2010
Supervisors: J.Kley (IGW – FSU, Jena), C.Dullo (IFM – Geomar, Kiel), M. Krbetschek (TU Freiberg), R.Freitag (BGR - Hannover)
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In this study, OSL dating was used to determine uplift rates on an active margin. The Kamchatka subduction zone is one of the most active convergent margins in the world. The Pacific Plate is subducting beneath the Kurile-Kamchatka margin since the Eocene, today with an average rate of 7.9 cm/a. Thereby the Peninsula is involved by strong neotectonic activities. Indicators of these activities on the eastern coastline are deformed Pleistocene sediments; recent thrust faulting and high uplifted marine terraces on different levels. The different levels of the elevated terraces points to variant uplift rates within the peninsula.

The geological records of marine terraces are the depositional and erosional remains of former

shorelines, so they are records of the former sea level. Along active continental margins, the marine terraces reflect the interplay between sea level oscillations and surface uplift. Dated marine terraces record the time of sea level high stands, but although the vertical crustal movement.

In the working area, 3-5 paleoshorelines are mapped via remote sensing. The aim of this study was to quantify the uplift from paleoshorelines by calculating uplift rates on OSL ages of marine terrace. Sediment age determination was carried out at the luminescence laboratory Freiberg (TU Freiberg /Inst. of Appl. Physics). The source materials of the marine terraces are mainly volcanic sediments. Because of a high fraction of magnetic material in these sediments, magnetic separation of sieved carbonate and organics free sediment fraction was used as an additional step for purifying the quartz within a procedure which furthermore applied feldspar flotation, density separation and HF etching. A single-aliquot regenerative-dose (SAR) procedure was used for palaeodose determination. It was necessary to add different hot-bleach treatments to the standard SAR-procedure based on a series of experiments. Broad statistical approaches on dose distribution in such samples from marine sedimentary environment have been applied.

This study presents the first quantitative results about age and uplift on the eastern coast of Kamchatka.

Author: Christopher Lüthgens
Thesis Title: The age of Weichselian main ice marginal positions in north-eastern Germany inferred from Optically Stimulated Luminescence (OSL) dating.
Grade: PhD
Date: February 2011
Supervisors: Margot Böse (Freie Universität), M. Krbetschek (TU Freiberg, single aliquot OSL), F. Preusser (University of Bern, single grain OSL)
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During the past 130 years, classification of the Weichselian Pleniglacial in north-eastern Germany was mainly based on morphostratigraphical interpretations. In general, three main ice marginal positions are distinguished. The ice advance to the southernmost, relatively weakly developed ice

marginal position of the Brandenburg phase has traditionally been ascribed to the Last Glacial Maximum (LGM) of the Scandinavian Ice Sheet (SIS). The Frankfurt phase is usually interpreted as a halt during the downmelting of the glacier. The most prominent ice marginal position in north-eastern Germany is that of the Pomeranian phase.

Owing to the absence of recent geochronological data of the Weichselian ice advances, the commonly used ages of ice marginal positions are only estimates or are based on extrapolations from ^{14}C ages of underlying organic sediments. However, during the past few years a number of studies have been conducted to set up a chronology based on geochronometrical data. In this study fluvioglacial sediments from outwash plains associated with the Brandenburg phase and the Pomeranian phase were dated by means of Optically Stimulated Luminescence (OSL) of single aliquots and single grains of quartz. Recently, additional ages from Surface Exposure Dating (SED) of erratic boulders using cosmogenic ^{10}Be have been published. To compare the results from these different approaches, the type and position of the sampled material within the glacial landscape system have to be considered. Consequently, different geomorphological processes are datable using either OSL or SED techniques. Therefore a process-based interpretation for numerical ages from OSL and SED in glacial landscapes is introduced.

From the results of the OSL analyses from the Brandenburg and Pomeranian phases as well as a thorough reassessment of the available ^{10}Be exposure ages, a synthesis was achieved in terms of ice dynamics and ice retreat patterns during Marine Isotope Stage (MIS) 2. One of the main findings is the evidence for a twofold LGM, with the older phase (LGM-1) corresponding to the Brandenburg phase, which was dated to <34 ka (maximum age), and the younger phase (LGM-2) represented by the Pomeranian phase, which was dated to 20.1 ± 1.6 ka (initial formation of outwash plains) and 19.4 ± 2.4 ka (final sedimentation of sandur sediments).

The first Weichselian deglaciation pattern for north-eastern Germany was established, based on results from numerical dating methods, and the last glacial-interglacial cycle was dated for the first time from a terrestrial Saalian-Eemian-Weichselian sedimentary sequence in the research area.

This thesis is available from: http://www.diss.fu-berlin.de/diss/receive/FUDISS_thesis_000000022882

Author: Femke Davids
Thesis Title: Optical dating of hurricane activity in New England, USA.
Grade: PhD
Date: September 2010
Supervisors: Geoff Duller, Helen Roberts
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This study has investigated hurricane activity during the late Holocene on the southern New England coastline (USA) by means of optical dating of overwash layers deposited in coastal salt marshes and ponds. Three alternative optical dating methods were investigated; quartz OSL, K-feldspar IRSL and the subtraction method. Both quartz and K-feldspar ages agree with independent age constraints (^{14}C) and are suitable for dating young hurricane overwash deposits. The majority of ages (53) were consistent with stratigraphical control.

Although K-feldspar ages were more precise, quartz was the most practicable method for this project considering the limited availability of sand grains in general, and K-feldspar specifically, in the thin overwash layers in this region. The signal analysis for quartz was improved by applying early background (EBG). A test on 13 samples demonstrated that EBG: 1) reduced the proportional influence of medium and slow components to the net signal; 2) reduced recuperation values; and 3) reduced the over dispersion value for some samples.

The D_e distributions from the overwash sediments showed both well bleached and heterogeneously bleached samples. The finite mixture model and the central age model were applied to determine the optical age. A modern analogue (hurricane Bob, AD 1991) was, moreover, very accurately and precisely dated with quartz minerals.

This study shows that determining the dose rate in heterogeneous sediment is challenging. Sensitivity analyses on the external dose rates demonstrated that variability in water content produced the most uncertainty in dose rates. Therefore, it is important to know not only the water content of the overwash layer but also of the bracketing layers. Furthermore, it was demonstrated that the dose rate should be corrected for organic content when samples have more than 5% organic content. Additionally, this study showed that X-ray core scanning can have an effect on the optical age of a sediment. Depending on the dose rate of the sediment, this could produce a significant offset to young geological samples, e.g. late Holocene.

The optical dating results from the six coastal salt marshes and ponds along the southern New England

coastline roughly indicate a period of activity between 2 - 1 ka before AD 2000 (*ca.* 6 major events), a period of less activity between 1 - 0.5 ka before AD 2000, and a period of high activity (*ca.* 7 major events) during the last 0.5 ka.

Author: Lara Wacha
Thesis Title: Luminescence dating of loess from the island of Susak in the Northern Adriatic Sea and the "Gorjanović loess section" from Vukovar in eastern Croatia.
Grade: PhD
Date: May 2011
Supervisors: Manfred Frechen (LIAG), Goran Durn (University of Zagreb)
Address: Leibniz Institute for Applied Geophysics (LIAG), Hannover, Germany

Loess-palaeosol sequences are an excellent high-resolution archive for palaeoenvironmental changes. They hide information about the past climate and climatic changes. To be able to reconstruct the palaeoenvironment it is common practice to investigate these deposits with a multidisciplinary approach. A detailed and reliable geochronology is mandatory to be able to interpret the results of such investigations.

The aim of this study was to establish a reliable chronological framework of loess-palaeosol sequences from Croatia. In Croatia two major loess regions can be distinguished, the North Adriatic loess region related to the river Po in North Italy and its tributaries and the Danube loess region in eastern Croatia. From both regions the most representative loess-palaeosol sequences were selected for investigations; the loess-palaeosol sequence on the island of Susak, where up to 90 m of Quaternary deposits, predominantly loess and loess derivatives were determined, and the "Gorjanović loess section" in Vukovar, which is the matter of scientific interest since the last centuries. These two genetically similar but in many ways different remains of climatic fluctuations during the Pleistocene were selected to be the topic for a detailed multi-proxy research for this PhD.

This geochronological framework is the first step in high-resolution investigations which is in progress. The dating was performed using infrared stimulated luminescence (IRSL) dating method, which is the method of choice for dating of Quaternary aeolian

deposits, as well as radiocarbon dating. Throughout this PhD several luminescence dating protocols were used; the multiple aliquot additive (MAAD) dose protocol which is a somewhat old-fashioned protocol was used for polymineral fine grain material separated from the loess from Susak for an easier correlation with older published data in this area; the single aliquot regenerative (SAR) protocol which is a widely used measuring protocol, with fading tests and fading corrections performed on the measured samples as well, to obtain more reliable dating results. For the “Gorjanović loess section” the post-IR IRSR protocol, which is a modified SAR protocol developed recently for dating of older deposits (Middle Pleistocene) was introduced. This protocol has the advantage that it can overcome the performance of fading tests and fading corrections since in this protocol more stable luminescence signals from feldspars are registered.

Using the above mentioned laboratory measuring protocols which were supported by numerous experiments and performance tests good and reliable geochronological frameworks for the sections under study were established. The results from the loess-palaeosol sequences on Susak show us that a very detailed record correlating to OIS5 (and possibly OIS6 or older) is preserved, unique in this region. Furthermore, based on the dating results as well as mineralogical and geochemical investigations the three tephra layers were correlated to South Italian volcanic provinces. The luminescence dating results are supported by the radiocarbon dating as well. The “Gorjanović loess section” is an example of the penultimate glacial- last interglacial – last glacial period (OIS6 – OIS2), as seen from the dating results, and can easily be correlated to similar loess-palaeosol sections in the region.

In this thesis a detailed and reliable chronological framework of prominent loess-palaeosol sequences in Croatia is established as well as a milestone for a stratigraphy of Quaternary deposits in Croatia.