Ancient TL

www.ancienttl.org · ISSN: 2693-0935

Ancient TL, 2011. *Thesis Abstracts.* Ancient TL 29(2): 75-77.
https://doi.org/10.26034/la.atl.2011.453

# Thesis Abstracts

**Author:** Roger Nathan
**Thesis Title:** Numerical modelling of environmental dose rate and its application to trapped-charge dating
**Grade:** D.Phil.
**Date:** Michaelmas 2010
**Supervisors:** Jean-Luc Schwenninger (Oxford), Ed Rhodes (UCLA)
**Address:** Research Lab. for Archaeology and the History of Art, Dyson-Perrins Building, South Parks Rd, Oxford OX1 3QY, UK

Accurate estimation of environmental dose rate is essential for high-resolution trapped-charge dating. Beta and gamma emissions from simulated sediments containing radioactive uranium, thorium and potassium are modelled in contexts that are spatially heterogeneous. Dose rate was modelled using Monte Carlo radiation transport codes MCNP and PENELOPE. A number of key issues that affect dose rate evaluation are examined and updated corrections are calculated.

Granular structures used for geometrical input into the models were simulated using randomly packed ellipsoids. The pair correlation function and chord length distributions were derived. The effects of water content on dose rate were modelled and compared with cavity theory. Apart from activity dilution, the variation of grain size or water content was shown to be significant for gamma radiations due to the transition from charged particle equilibrium. The standard correction for beta dose rate due to grain size was found to be satisfactory although sensitivity to grain shape and material should be taken into account.

Dose rate modeling was applied to three dating studies of early human fossils: Skhul V, Israel skull; Hofmeyr, South Africa skull and the Forbes' Quarry, Gibraltar skull. The spatial modelling was implemented using computerised tomographic (CT) images and dose rate found to be modified significantly by the presence of the skull in the sediment. Time evolution of the dose rate was examined for the latter two skulls and dates of 36±3ka (Hofmeyr) and 55-95ka (Forbes' Quarry) were calculated.

This thesis is available as a PDF from: www.aber.ac.uk/ancient-tl

**Author:** Thomas Rosenberg
**Thesis Title:** Palaeoclimate history of the Arabian Peninsula: humid phases recorded in lake deposits
**Grade:** PhD
**Date:** November 2011
**Supervisors:** Frank Preusser (Stockholm), Dominik Fleitmann (Bern), Albert Matter (Bern)
**Address:** Institute of Geological Sciences, University of Bern, Switzerland

The dispersal of anatomically modern humans (AMH, *Homo sapiens*) out of Africa is a pivotal event in the global expansion of our species. As the major dispersal routes cut through the vast Arabian Desert, favourable climatic and environmental conditions with sufficient supply of surface water must have been critical factors for AMH expansion into Arabia and beyond. The modern climate of Arabia is governed by subtropical high pressure with very scarce moisture, generally delivered by the northwesterly winds. A limited area in the far south experiences tropical summer precipitation under the influence of the Indian Summer Monsoon. From regional climate archives it is known, that the northern limit of monsoon rainfall was highly variable in the past, reaching latitudinal positions far north of its present summer position. How far north, however, remains unknown because of large gaps between clusters of existing climate archives. Relict lake deposits scattered among the dunes are the primary repository of past climate conditions in Arabia due to their potential to record environmental conditions during humid periods. Yet, until a few years ago, dating of Pleistocene relict lake deposits was limited to contaminated radiocarbon ages of the 70s, systematically underestimating the real ages. Hence, this PhD study focused on re-dating the relict lake deposits using optically stimulated luminescence (OSL). Owing to early signal saturation, the OSL dating limit was reached at ages of ~100 ka and required the testing of a novel measuring protocol to expand the dating range (TT-OSL). Application of the approved protocol on samples from south-western Saudi Arabia revealed humid phases with a savannah like environment at ~80 ka (MIS 5a), ~100 ka (MIS 5c) and ~125 ka (MIS 5e). A second study on fluvial and lacustrine deposits in the interior of Oman, suggested a short humid period sometime between 132 and 104 ka. A final study on relict lake deposits from northern Saudi Arabia indicated humid periods

centred at ~410, 320, 125 and 100 ka. A comparison with speleothem records of the southern Negev desert shows a very similar timing for humid periods. The agreement with the southern Negev, and disagreement with the central and northern Negev, makes a Mediterranean moisture source unlikely and suggests a tropical source, possibly from an enhanced African Monsoon. Favourable environmental conditions during all these periods allowed AMH to migrate across Arabia. Between ~75 and 10.5 ka arid conditions prevailed and turned Arabia into a natural barrier for human dispersal. Thus, expansion of AMH into Arabia and beyond must have taken place before 75 ka, possibly in multiple dispersals.

**Author:** Tobias Lauer
**Thesis Title:** Luminescence and infrared-radiofluorescence dating of fluvial deposits from the Rhine system – methodological aspects and new insights into Quaternary geochronology
**Grade:** PhD
**Date:** 2011
**Supervisors:** Manfred Frechen, Matthias Krbetschek, Sumiko Tsukamoto
**Address:** Leibniz Institute for Applied Geophysics, Hannover and Fachbereich Geowissenschaften der Freien Universität Berlin, Germany

Fluvial aggradation and erosion is triggered by mechanisms like climate variations, tectonics, sea-level change and human impact. The Rhine system is one of the largest drainage systems in Europe and its sediments therefore provide important information about the palaeo-climate and tectonic evolution of Central Europe. To understand at what time for instance tectonic impulses or changes in climate, regulating sediment supply and sediment preservation, occurred, a reliable chronology for the fluvial sediments is mandatory.

In this thesis Luminescence and Infrared Radiofluorescence (IR-RF) dating were applied to fluvial deposited collected from the Heidelberg Basin (northern Upper Rhine Graben) and Lower Rhine Embayment, Germany. Optical dating of fluvial deposits is still challenging because in many cases the luminescence or IR-RF signal was not reset completely before burial. Further problems like feldspar impurities disturbing the quartz-OSL signal or a weak luminescence signal (bad signal to noise ratio) of quartz can occur. Potassium feldspar gives much more luminescence (higher signal intensity) but it is affected by anomalous fading which has to be corrected. Fading corrections are problematic especially for old sediments. One aim of this thesis was to better overcome these problems and to contribute to the methodological progress among optical dating with focus on fluvial deposits. To do so, different dating approaches were tested on fluvial samples for which age control is available. Furthermore it was intended to establish a better chronological framework for Holocene, Upper and Middle Pleistocene fluvial sediments from the Rhine system.

The sediments in the Heidelberg Basin are characterized by heterogeneous, gravel-rich layers (cold stage deposits) and intercalated fine-grained layers hosting organic material (so called Interlayer). The latter were deposited during warmer climate periods. It was intended to obtain a reliable chronology for both, the warm stage and cold stage deposits. The quartz OSL ages demonstrate that the upper fluvial units (sediments above the Upper Interlayer) were deposited during the Last Glacial period (Weichselian).

To frame the sedimentation age of the Upper Interlayer and sediments below, IR-RF was used. For the Upper Interlayer the IR-RF ages point to a sedimentation age of ~ 300 ka. This shows that there is a huge chronological gap between the Weichselian fluvial sediments and this interlayer. For the fluvial units below the Upper Interlayer it was possible to date up to ~ 640 ka (100 m core depth at the Viernheim drilling site). For the Middle Pleistocene differences in the intensity of subsidence of the Heidelberg Basin mainly regulated the fluvial aggradation. During times of increased subsidence, accumulation space was created and the sediments could be preserved. Hence, the IR-RF ages help now to better estimate the timing of subsidence of the Heidelberg Basin.

For the Lower Rhine the luminescence ages now yield a higher chronological resolution for the studied sections (mainly Lower Terrace) and help to better understand the past fluvial dynamics of the Rhine. It could for instance be shown that fluvial aggradation of many meters of sediments can happen within a very short time period. Samples which were taken with a vertical distance of > 5 meters from a section at Monheim-Hitdorf all yield equal OSL ages.

For some of the samples taken at the LRE independent age control was provided by Laacher See pumice (age ~ 12.9 ka). For these samples quartz OSL and feldspar measurements were conducted and the results were checked against the age control. For feldspar dating, the IRSL at 50°C was measured and after this, the post-IRSL signal was detected stimulated with red LED at 225°C (pIRIR signal).

Next to this a new protocol was applied which includes the detection of a feldspar signal stimulated with yellow LED at 260°C after depleting the IRSL (50°C) signal (pIR-YOSL). The latter protocol was developed within this thesis.

It turned out that quartz dating worked well for the fluvial samples under study. The ages are in agreement with the age control and also the feldspar dating results agree with the quartz ages.

Further samples were taken from a Roman harbour exposed at Cologne. For these samples Roman artefacts gave a very precise age control. This gave the opportunity to test different statistical approaches for these incompletely bleached sands. Furthermore, different protocols were applied to minimize the feldspar signal in contaminated quartz and it was shown that pulsed OSL but also an IRSL bleach at 225°C prior to the detection of the quartz (blue stimulated) signal have very good potential to obtain a purer quartz signal.

The results which are presented in this thesis show that luminescence and IR-RF dating are powerful tools to establish a reliable chronological framework for fluvial deposits. There are still challenges (e.g. which statistical approach one should apply if samples are incompletely bleached). Nevertheless, the here applied dating approaches yielded reliable ages as for example demonstrated by quartz and feldspar ages from the Monheim-Hitdorf site (Lower Rhine). It was also of high relevance to point out that IR-RF dating could successfully be applied to samples being older than 600 ka.

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