DATING THE ROMANIAN PART OF THE EUROPEAN LOESS BELT USING LUMINESCENCE METHODS (DAROLUM)
Project leader

Scientific visibility and prestige

Main research results.

The project leader started her scientific activity in 2006 when she enrolled in a PhD program, which she graduated in 2010 by submitting a thesis entitled “Retrospective luminescence dosimetry: Applications in Archaeology, Geology and Environmental Studies”. The overriding objective of the thesis was to implement luminescence dating at Babes-Bolyai University in Cluj Napoca and apply state of the art dating technology to materials that are relevant to archaeology and earth sciences. The work that has been accomplished though went far beyond mere implementation and application and it was a fundamental contribution to the field of luminescence dating. The work on dating Neolithic ceramics from Lumea Noua is one of the few studies available in international literature that applied a single aliquot state-of-the-art dating protocol technology to ceramics. The dates provided the first direct and absolute age information for the cultural development at the site, and in general, demonstrated the potential of modern SAR-IRSL and SAR-OSL techniques for improving the chronological framework of archaeological sites. During the course of her PhD (October 2006-June 2010) and up to the moment of writing this proposal the project leader carried out fundamental and applied luminescence research on luminescence of quartz extracted from Romanian loess. It is widely accepted that Romanian loess/palaeosol sequences represent important and detailed archives of regional climate and environmental change during the Pleistocene. However, prior to the studies of the applicant, very little absolute age information was available for these deposits. The applicant applied a modern SAR-OSL technique to quartz grains extracted from loess deposits at two “key sections” in SE Romania, Mircea Voda and Mostistea. At both localities, the quartz-based SAR-OSL dates demonstrated that the uppermost loess/palaeosol unit represents the Last Glacial/Interglacial cycle. These results urge that the old-established chronostratigraphical framework must be revised, in that the S1 unit can no longer be considered a soil that developed during a Last Glacial interstadial. By extrapolation, the same holds true for the underlying S2 unit. For the section near Mircea Vodă the dates obtained also demonstrate that that the L1 unit did not accumulate at a constant rate, with loess being deposited at a much lower rate during the past 70ka. Loess is generally considered as an ideal material for testing and applying luminescence techniques; however a comparison of SAR-OSL ages for silt and sand-sized quartz obtained by the current proposal’s project leader convincingly demonstrated that loess may be one of the most difficult materials to date. Her previous studies and on-going studies caution against blind application of
modern techniques to this type of material and challenge the luminescence dating community to develop more robust luminescence dating procedures.

The accomplishments of the current proposal’s team leader can be summed up as follows: (i) she contributed significantly to the set up of a modern luminescence dating laboratory in Cluj and on the implementation of luminescence dating techniques in Romania; (ii) she demonstrated that modern luminescence dating techniques hold considerable potential for dating heated archaeological materials, especially if these can not be dated by other means; (iii) her work on Romanian loess challenged the earth scientific community in their conventional interpretation of these records and the luminescence dating community in their assumption that loess is an ideal and non-problematic material for luminescence dating.

*The visibility of the scientific contributions.*

For part of her work on Romanian loess A. Timar-Gabor received the “Vagn Mejdahl for her outstanding presentation at the “12th International Conference on Luminescence and Electron Spin Resonance Dating (LED 2008)” which was held in Beijing 18–22 September 2008. This is a very prestigious prize awarded at the most important scientific meeting for the luminescence dating community. This is mentioned in the editorials of two highly ranked journals (for more information please see Radiation Measurements 44 (2009) p. 415–416, Quaternary Geochronology 5 (2010) p.83).

As a consequence to the contribution to LED 2008 A. Timar-Gabor was invited to give a talk at Qinghai Institute of Salt Lakes (Chinese Academy of Sciences), Xinning, China- 24-25 September 2008 (http://www.isl.cas.cn/xwzx/xshd/200906/t20090607_573264.html).

In 2008 A. Timar-Gabor was offered a PhD position in Risø National Laboratory (the forefront of luminescence dating research) under the supervision of Professor Dr. Andrew Murray. The present applicant has chosen however to continue her activity in Romania. At the moment A. Timar-Gabor has informal scientific collaborations through transfer of knowledge with other researchers in the field of luminescence dating such as Dr. D. Vandenberghe (Ghent University) or Dr. György Sipos (University of Szeged). Recently, A. Timar-Gabor started a collaboration with one of the most prestigious researchers in luminescence dating -Professor Ann Grace Wintle (Cambridge University and University of Wales Aberystwyth). This collaboration aims at fundamental research into the luminescence of quartz and will result in a joint presentation at “12th International Conference on Luminescence and Electron Spin Resonance Dating (LED 2011)” which was held in Torun, Poland 10–15 July 2011.

During her scientific activity (2006-2011) A. Timar-Gabor participated in 13 international conferences with 7 oral presentations and 6 poster presentations.
Project description

Scientific context and motivation.

A better comprehension of past and current climate variability requires the integration of multiple data sources, either empirical or mathematically modeled. Therefore, a wealth of paleoclimatic information has been obtained in the past decades by the investigation at unprecedented details of a variety of proxies and archives worldwide. Nevertheless, compared with other parts of Europe, limited paleoclimate information is currently available from South-Eastern Europe, and especially from Romania, even though this region could be of particular interest for understanding past climatic dynamics at both regional and continental scales. Loess originated mainly from silty material blown out of sparsely vegetated areas during the dry and cold periods of the Pleistocene while during interglacials and most interstadials, the loess sedimentation areas were covered by newly formed soils. Thus, the alternation of cold and warm periods throughout the Quaternary led to the formation of interbeded loess-palaeosol sequences (LPSS), some of the most detailed terrestrial archives of climate and environmental change. Marine records and ice core records primarily record global climate signals, whereas loess/palaeosol additionally reflect regional and climate and environmental conditions (Frechen, 2011). However, because significant lateral variation in both physical and chronological parameters may occur over large distance, their significance can only be fully and securely understood if an absolute chronology is developed for each investigated profile (Frechen et al., 2003, Roberts, 2008). Application of newly developed absolute dating methods fit for loess research and notably the luminescence dating method produced convincing evidence that loess deposits could be affected by varying accumulation rates and erosive hiatuses (see for example Stevens 2007, Buylaert 2008). These new findings call for a re-evaluation of some of the previously established facts concerning the nature, formation and significance of loess records, and question the utility of simple stratigraphic correlation of several palaeosols as stratigraphic markers, especially in the absence of any chronological constrains. Consequently, absolute dates in loess-related research are essential to determine (i) the timing of climatic events that are registered in the loess, (ii) the rate of processes such as sedimentation and pedogenesis and (iii) the correlation between different loess sequences.

Loess deposits cover significant areas in Europe, extending from NW-France and Belgium through to Central Europe, the Ukraine and Western Russia (Hasse et al., 2007, Zoeller, 2010). The LPSS of the Carpathian Basin-Lower Danube region (Romania, Serbia, Bulgaria) are thought to represent the most continuous and high resolution archives of regional climate and environmental change during the Late and Middle Pleistocene, in this part of Europe and a link between similar deposits in central Europe and Eurasia.
In comparison to other loess sequences elsewhere in Western, Central and Eastern Europe, the deposits in Romania have been much less extensively studied (Frechen et al., 2003). A chronostratigraphical framework for the Romanian loess deposits has previously been established through geomorphological, lithological and pedostratigraphical analyses (Conea, 1969, 1970) while more recent studies of the magnetic properties of the LPSS have demonstrated the potential of magnetic susceptibility as a climatic proxy (see e.g. Panaiotu et al., 2001; Buggle et al., 2009).

Luminescence dating allows the direct determination of depositional ages for sediments from a wide variety of depositional environments, and especially aeolian sediments (Murray and Olley, 2002). However, the dating of loess deposits in Romania by luminescence methods is just at the beginning. In the exploratory study by Balescu et al. (2003), four IRLS ages were obtained for a section near Tuzla (Dobrogea, SE Romania). Despite the limited dataset, they could demonstrate that the uppermost palaeosol in the section was formed during MIS5 and that the first three loess layers accumulated during the last three glacial periods (MIS 4, MIS 6, respectively MIS 8). So far, the current proposal’s research group have intensively investigated two “key sections” in SE Romania. The first section (~26 m thick) is located near Mircea Vodă (Timar et al. 2010, Timar-Gabor et al. 2010) and it comprises six well developed palaeosols (stratigraphic nomenclature: S0-S5, with S0 representing the Holocene soil) and intercalated loess layers (L1-L6), with no apparent evidence for large hiatuses. The L1 unit also contains a weakly-developed palaeosol. The second section is located on the border of Mostiște lake (Vasiliniuc et al. 2011). It is ~21 m thick and consists of four loess-palaeosol units and the Holocene topsoil. Our research design and strategy consisted of sampling the sections at a high vertical resolution (preferably ~20-30cm). The chronometric investigations focussed on the L1/S1/L2 sequence and involved the SAR protocol and OSL signals from quartz. At both localities, the quartz-based SAR-OSL dates demonstrate that the uppermost loess/palaeosol unit represents the Last Glacial/Interglacial cycle. These results support the conclusions of Balescu et al. (2003, 2010) and urge that the old-established chronostratigraphical framework (Conea 1969, 1970) must be revised, in that the S1 unit can no longer be regarded as a soil that developed during a Last Glacial interstadial. By extrapolation, the same holds for the underlying S2 unit. For the section near Mircea Vodă, the dataset indicates that the L1 unit did not accumulate at a constant rate, with loess being deposited at a much lower rate during the past 70ka. So far, we did not observe any hiatuses in the record (within the limits on the time-resolution that can be achieved using quartz-based SAR-OSL dating), but it does appear that the rate of loess deposition during MIS5 differs between the two localities. As tight independent age control is lacking, the optical ages are probably the best chronological data currently available for these sites. Our studies demonstrates that quartz-based SAR-OSL dating is a powerful tool to spatially and temporally correlate Romanian loess-palaeosol sequences, and to assess the validity of
proxy-based methods for timing and reconstructing climatic and environmental change. This proposal aims at deepening and extending the preceding work both in terms of the study areas covered as well as and the dating methodology.

C2. Objectives.

The main objective of this project is to establish an accurate and precise chronology for some of the most important loess sequences in Romania. This approach is essential for (i) securely linking loess records from Romania in a chronologically reliable regional framework (including information from the better investigated and well-known Danube loess sites in Serbia and Bulgaria), and to extend this information to other sites from central and eastern European loess belt, in order to understand past paleoenvironmental dynamics at both regional and continental scales. To achieve these goals, the sediments will be dated using luminescence methods for establishing a reliable and detailed chronology for sediments that have been deposited during the last Glacial/Interglacial cycle (i.e. last ~130ka, MIS2-5), and if possible, for earlier cycles as well. Additionally, high-resolution sedimentological, geochemical and rock- and paleomagnetic measurements will be carried out for the investigated sections. Luminescence dates will be compared with the sedimentological data and the magnetic susceptibility based time depth model an initiative which should allow producing a detailed multi-approach age model, with immediate application in interregional correlations and on the reconstruction of climate and environmental gradients using a common temporal framework.

Method and approach.

Field work and sampling strategy

Potential sampling sites will be surveyed and selected in collaboration with field specialists. These key sections (see figure) represent the most complete and/or detailed palaeoclimatic and palaeoenvironmental records for S Romania and cover several glacial/interglacial cycles. The youngest loess (L1) will be sampled at a high vertical resolution (e.g. every 20-30cm); the older loess deposits will be sampled with a larger vertical spacing.

Costinesti section: Consisting of five palaeosoil layers and interbedded loess, the loess-palaeosoil section from Costinești is located on the Black Sea shore (43, 97 °N 28,65 °E), north of Costinești village. L1 has a thickness of approx. 1.20 m and L2 approx. 2.15 m. High resolution sampling (10 - 20 cm) has been already performed for the first two loess layers (L1 and L2) and from S1.

Turnu Magurele area: The sections are located north of Turnu Magurele between Slobozia Mandra and Lunca localities. The sections comprise of 30-35m of aeolian deposits (loess, sands) with 6-7
interbedded paleosoils and several volcanic-ash layers. The area will be sampled in spring-summer-autumn 2012.

**Map of loess distribution in Europe (Haase et al., 2007) (right). The locations which will be investigated are depicted with red ovals. Map of Romania (left-side) depicting (in gray) the loess and loess like deposits. The previously studied sections (Mostistea and Mircea Voda are represented as open circles. The profiles that will be the subject of the current proposal are depicted as stars.**

**Focsani area:** In the area between the riverbeds of Putna, Ramnicu Sarat and the left bank of Siret River there are several deposits with thickness of 10-20m. These deposits are of major importance because of the peculiarity of the loess which is coarser than in the typical deposits of Danube Plain—probably due to the proximity of one of the source areas (the Carpathians). Due to the tectonic movement in the area at several locations gravel beds are intercalated. We envisage that dating of these deposits will contribute in improving the modeling tectonic movement as well. The area will be sampled in spring-summer-autumn 2012.

**Semlac:** The profile at Semlac (thickness of 15 m) will be studied as it has major importance for correlating the deposits in SE Romania (previously studied and described in this proposal) to the very intensively studied deposits in Central Europe (see e.g. Ujvari et al. 2010, Stevens et al. 2011, Markovic et al. 2011). The area will be sampled in spring-summer-autumn 2012. Other locations that are of interest will be also sampled occasionally to test for their records. As an example we indicate the sites of **Daneasa** (Olt river) and **Caciulatesti** (Jiu river) where tephra layers have been identified intercalated between loess and loess-like deposits.
Dating methodology

Our high resolution dating studies and multi proxy approach is intended to overcome limitations of the paleoclimatic and dating methods. As far as the luminescence dating methodology is concerned, it seems appropriate to start where previous work has ended. Therefore, the investigations will begin by documenting the OSL characteristics of silt (4-11µm) and sand-sized (63-90µm) quartz grains extracted from the samples. Research efforts will concentrate on the applicability and performance of the single- aliquot regenerative-dose (SAR) OSL technique (Murray and Wintle 2000, 2003, Wintle and Murray 2006); this technique uses a minimum amount of pure quartz (i.e. a few mg on a single aliquot) and blue light as the signal stimulation source. In a following phase, an in-depth study of the luminescence characteristics of polyn mineral fine-grains and coarse feldspar grains will be performed, including investigations on whether or not it is possible to minimize anomalous fading. Finally, innovative and very new luminescence techniques such as TT-OSL (Wang 2007) and isothermal decay (Vandenberghe 2009) will be applied. Luminescence dates/respectively mass accumulation rates derived from determined absolute ages will be compared to the grain size distributions and a novel magnetic susceptibility time depth model.

Impact, relevance, applications.

The strength of the project lies both in its interdisciplinary and multidisciplinary approach as well as on the foreseen broad scientific impact. The study proposed here should establish a final and reliable absolute chronological framework for some of the most important loess sequences in Romania. As such, it will contribute significantly to improving the understanding of stratigraphic and chronological relations between local and regional geological sequences, a necessary preamble for securely linking the Lower Danube loess deposits with comparable sequences elsewhere in Europe and Eurasia. The age results will also yield precise information on loess accumulation rates and through complementary analyses, could lead to better understanding of the importance of past atmospheric circulation patterns and related dust fluxes as both records and a potential agents of climate change. The proposed project will also capitalize important contributions to the efforts made by the international community to improve both the protocols of the luminescence method and to extend its temporal range. A luminescence dating method yielding reliable ages over an extended time-span will undoubtedly mark a completely new chapter in the study of earth surface processes, human evolution and terrestrial climate change. This project will also produce crucial new developments concerning the charge storage, movement and recombination in non-conducting crystalline solids, and the use of these phenomena in the measurement of absorbed radiation dose. Last but not least, it is hoped that the implementation of the current project proposal will lead to the
development of a multi and interdisciplinary team of young specialists in paleoclimate research based on absolute numerical investigation techniques in Romania.

References:


