

Thesis Abstracts

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Anca Avram

Multi-method luminescence dating studies using quartz and feldspars extracted from loess deposits in Europe, Asia and Oceania

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Degree: Ph.D.

Supervisor: Prof. Alida Timar-Gabor

The applicability of the Single-Aliquot Regenerative-dose (SAR-OSL) protocol on quartz as well as the post infrared-infrared protocols (pIRIR₂₂₅ and pIRIR₂₉₀) on polymineral fine grains was assessed for dating loess distributed over three continents, namely Europe (Batajnica section, Serbia), Asia (XuYi profile south-eastern China) and Oceania (South Island of New Zealand).

Since it is well known that feldspars are more difficult to bleach than quartz, residual dose measurements were performed prior to age calculation. Several experiments were carried out, such as: investigating the dependency of the residual as function of the exposure time to sunlight (from 0.5 h to 30 days), or the investigation of the dependency of the residual dose on the equivalent dose magnitude, as well as on the magnitude of various large laboratory given doses (up to 800 Gy). The results showed that pIRIR₂₉₀ signal is more slowly bleached than pIRIR₂₂₅ and the residual doses measured using pIRIR₂₉₀ protocol are larger than those measured by the application of the pIRIR₂₂₅ protocol. Assuming that the measured residual originates from an unbleachable component that is not dose dependent and the values measured in young samples are actually the result of insufficient exposure to light, a time which is characteristic to all samples investigated in a sedimentary context, if the bleaching time is maintained to a fixed period during solar simulator experiments on different samples, then a linear dependency is expected between the equivalent dose of the investigated samples and the measured residual dose values. Therefore, a minimum residual dose corresponding to the unbleachable part of the signal can be determined by extrapolating measured residual dose values to an equivalent dose equal to 0 Gy ($D_e = 0$ Gy). In the absence of information from modern analogues, which is

a common scenario in many dating contexts, this is the most reasonable value to be subtracted from the measured equivalent dose when age calculation is performed.

Since it is unanimously accepted that quartz does not suffer from any signal loss, fading measurements were carried out on polymineral fine grains extracted from loess from Serbia, China and New Zealand by comparison to quartz. Our results show that fading is insignificant for pIRIR₂₂₅ signals.

The performance of the dose recovery tests was extensively investigated for pIRIR protocols by varying both the magnitude of the given dose as well as the magnitude of the test dose. Our results indicate that the pIRIR₂₂₅ protocol can accurately (less than 10% deviation) recover known doses up to ~300–400 Gy while the application of pIRIR₂₉₀ protocols results in measuring doses that slightly overestimate the given dose for the entire dose range (100–800 Gy) investigated, the overestimation ranging from 12% to 61% and being more significant for larger doses.

While the applicability of the SAR-OSL protocol on New Zealand quartz was hampered by the low luminescence sensitivity of the material, the application of the SAR-OSL protocol on quartz extracted from Serbian and Chinese loess resulted in obtaining robust chronologies for ages up to about 70 ka. Based on the comparison of the natural and laboratory dose response curves for Batajnica samples in Serbia it was concluded that fine and coarse quartz luminescence ages can be accurately measured for samples with equivalent doses up to ~150 Gy and ~250 Gy, respectively. On the other hand, for the investigated samples the datable dose range can be extended by using feldspars up to 400 Gy. However, the results obtained for equivalent doses larger than 400 Gy should be interpreted with caution in the absence of independent age control for both pIRIR protocols. Overall, our results show that pIRIR protocols can be applied successfully on polymineral fine grains extracted from loess deposits over three continents for extending the quartz datable age range.

Laura del Valle Villalonga

Pleistocene deposits of Pityusic Islands: architecture, luminescence chronology and paleoclimatic implications

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Coastal areas are dynamic territories that are subjected to the confluence of many factors and agents that are caus-

ing transformations. These modifications and their causes can be identified from the geomorphological evidence. The study of the Pleistocene deposits of Pityusic islands can provide a very good source of information for gaining better knowledge on the history of the climate and environmental conditions, as well as the geomorphological processes that occurred during the Quaternary. This study deals with the sedimentological and stratigraphic description of Pleistocene coastal deposits of the Pityusic Islands that show evidence of interference between processes characteristic of alluvial, marine and aeolian environments. Optically stimulated luminescence (OSL) dating of aeolian levels indicates that deposition took place from the Lower to Upper Pleistocene. The sedimentological and chronological analysis of these deposits allows reconstructing of the coastal Pleistocene environmental history from Marine Isotopic Stage (MIS) 22 to MIS 3. Results show that the main controls on Lower to Upper Pleistocene coastal landscape evolution on Eivissa, Es Freus and Formentera are changes in the average wind direction over time, modulated by the interaction with coastal relief orientation. The main episodes of aeolian activity identified and dune formation in the Western Mediterranean can be linked to periods of low sea level. We conclude that although there were two prevailing environments such as coastal aeolian and alluvial, with different processes and resulting forms, the interaction resulted in deposits that share characteristics of both environments, as well as maintain elements inherited from each environment in terms of sedimentary supply, precipitation, runoff or aeolian transport. Our results are a useful indicator of the geomorphological processes and changes that occurred during the Pleistocene, unravelling the environmental evolution, and contributing to the growing knowledge on the Western Mediterranean aeolian or aeolian-alluvial interacting environments.

Patricia Mescolotti

Fluvial plain and eolian dune field of the middle São Francisco River: chronology of deposits and succession of geological events in the Quaternary of Brazil

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Large rivers, with São Francisco, are dynamic systems whose evolution depends on both internal and external forcing, particularly tectonics, sea level, and climate. The São Francisco River is the easternmost large river of South America, with its upper course in semi-humid settings, but with a watershed mostly under semi-arid conditions. As this is a river with its basin in tectonically quiescent areas and controlled by local base level, the São Francisco River's deposits are an excellent fluvial sedimentary record to shed light on how large tropical rivers responded to climatic changes of

the Quaternary. Directly associated with the São Francisco River, the Xique-Xique eolian system is the largest Quaternary interior dune field in Brazil (~8,000 km²). Aiming to establish the chronology of the deposits and the evolution of quaternary geological events for the Xique-Xique dune field and for the alluvial deposits of the São Francisco River, we investigated a 200-km section of the medium course of the São Francisco River in Bahia, northeast Brazil. We use a multi-method approach, using remote sensing methods and field surveys for geomorphological and sedimentological analyses combined with optically stimulated luminescence dating (OSL). Several fluvial and eolian geomorphological zones were characterized, mapped, and dated. Two zones are represented by degraded terraces, and three zones comprise the active confined aggradational plain. We recognized at least four phases of fluvial aggradation (>90 ka; 65 to 39 ka; 18 to 9.5 ka and 380 years to recent) and three phases of incision (I1 – 85 to 65 ka; I2 – 39 to 18 ka and I3 – 9.5 to 1.0 ka). The eolian field initially developed at least since ~250 ka and comprises predominantly stabilized parabolic dunes (simple and compound), sand sheet and modern active parabolic dunes. We recognized two main events of eolian activity (~23 to 18 ka and ~15 to 10 ka) and two phases of dune stabilization (~18 to 15 ka and since 5 ka). We interpret that the two large systems studied here (fluvial and eolian) interact with each other and respond differently to climatic triggers, particularly precipitation. The incision events occurred probably due to increased fluvial discharge produced by intensification of the South Atlantic Convergence Zone, which has great influence on precipitation over the upper São Francisco River. Thus, we conclude that the aggradation-incision cycles of the São Francisco River during the last 100 ka are likely products of millennial precipitation variation. As for the eolian dynamics, the changes in precipitation in the area mainly influenced the process of stabilization of the dunes by vegetation, especially in the humid HS1 (Heinrich 1 event). However, the moments of dune activity were more conditioned by changes in the river sediment supply. Thus, eolian events are closely related to incision/fluvial deposition events in the area, providing an exceptional case of fluvial-eolian interaction in the Quaternary of Brazil. The Xique-Xique eolian system results from the conjugation of sediment carried mostly from the river, high eastern wind speeds, and a significant wind deceleration caused by mountains on the western border of the dune field.

Mariana Sontag González

Development and application of luminescence approaches to dating of Indonesian archaeological and palaeoanthropological sites

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Establishing reliable chronologies for archaeological and

palaeoanthropological sites in Indonesia is important for studies of human evolution and dispersal. However, many such sites are situated in volcanic regions, whose sediments are generally difficult to date using luminescence dating methods. Here, the application of improved procedures using the post-infrared infrared stimulated luminescence (pIRIR) signal targeted to dating volcanic sediments is presented on two case studies of archaeological sites in Indonesia with an extended hominin occupation in the Pleistocene: Liang Bua and Leang Bulu Bettue.

Individual mineral grains deposited at Liang Bua, the type locality of *Homo floresiensis*, on Flores, Indonesia, that emit detectable pIRIR signals are composed of a range of feldspar varieties, quartz, clay minerals, heavy minerals and volcanic glass, rendering the isolation of individual potassium-rich feldspar grains infeasible. The luminescence behaviour of these composite mineral grains was investigated in detail, including their thermal stability, anomalous fading and dose-response characteristics. A standardised growth curve (SGC) was developed to enable more time-efficient measurements, together with a ‘micro-aliquot’ approach in which each hole on a disc contains approximately 8–10 grains. Less than 1% of grains yield detectable pIRIR signals when measured individually, so the use of micro-aliquots provides an effective means of estimating the equivalent dose (D_e) at single-grain resolution. The performance tests suggest that the pIRIR signal measured at 275 °C is suitable for estimating D_e values of these composite grains, without the need for residual dose or fading corrections. Internal dose rates were calculated incorporating information on the mineralogical compositions of individual grains that emit a pIRIR signal. Additionally, spatially-resolved beta dose rates from a Timepix pixelated detector informed on the expected scatter of luminescence signal intensities caused by beta dose rate heterogeneity. A total of 41 samples dated with these procedures, from contexts ranging from the basal sediments underlying the *H. floresiensis*-bearing deposits up to the layers with evidence of occupation by anatomically modern humans, were included in a Bayesian model yielding a refined chronostratigraphy for this important site.

Located in the Maros karst region of southwest Sulawesi, the second study site, Leang Bulu Bettue, contains evidence for human symbolic behaviour from ~30,000 years ago. Previous research at this site reported high fading rates for K-rich feldspar grains measured using a single-aliquot pIRIR procedure. In this study, the SGC pIRIR procedure for micro-aliquots, at effectively single-grain resolution, was used to (i) test its reliability for D_e estimation and subsequent age determination, and (ii) show that, in contrast to the high fading observed for single aliquots using IR diodes for stimulation, the micro-aliquot results obtained using an IR laser show a low fading rate. The reduced fading rate of the pIRIR signal using the new procedure is due to the selection of low-fading bright grains from a population of grains with mixed fading rates. Additionally, the presence of outlier and insufficiently bleached grains was considered in the choice of age models used for D_e deter-

mination. New pIRIR ages at single-grain resolution support the use of these methods to date dim volcanic samples with minimal fading corrections, allowing for an extension of the known chronology of hominin occupation at the site. A PDF of this thesis is available upon request (Mariana.Sontag-Gonzalez@geogr.uni-giessen.de)