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Thesis Abstracts

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Hayley Candice Cawthra

The Marine Geology of Mossel Bay, South Africa

May 2014

Department of Geological Sciences, Faculty of Science, University of Cape Town

Degree: Ph.D.

Supervisor: John S. Compton

This thesis presents work undertaken to better understand the complex evolution of the terrestrial landscape now submerged by high sea levels offshore of Mossel Bay along the South Coast of South Africa. Three marine geophysical surveys and scuba diving were used to examine evidence of past sea-level fluctuations and interpret geological deposits on the seafloor. Additional geological mapping of coastal outcrops was carried out to link land and sea features and rock samples were dated using Optically Stimulated Luminescence (OSL). Geophysical investigations include a regional seismic survey extending from Still Bay in the west to Buffels Bay in the east out to a maximum water depth of 110 m; a high-resolution investigation of the Mossel Bay shelf using multi-beam bathymetry, side-scan sonar and sub-bottom profiling; and a shallow seismic pinger survey of Swartvlei, the most prominent coastal lake in the Wilderness Embayment. This study presents 9 discrete seismic sequences, and describes major offshore geomorphic features such as submerged sea cliffs, palaeo-coastal zones and fluvial systems. Oscillation in sea level between ~2.7 and 0.9 Ma likely resulted in the formation of the prominent -45 m terrace, which separates a relatively steep inner from a low-gradient mid shelf. Beach and dune deposits span from Marine Isotope Stage 15 (MIS 15) (582 ka) to Recent based on an age model that integrates OSL ages and the established eustatic sea-level record. The most prominent deposits date from the MIS 6 glacial to MIS 5 interglacial periods and include incised lowstand river channels and regressive aeolianites that extended at least 10 km inland from their associated palaeoshorelines. The MIS 5

deposits include transgressive beachrock, an extensive fore-shore unit which prograded on the MIS 5e highstand, and regressive beach and dune deposits on the shelf associated with the subsequent fall in sea level. MIS 4 lowstand incised river channels were infilled with sediment truncated during rapid landward shoreface migration at the MIS 4 termination. Low-energy, back-barrier MIS 4/3 sediments are preserved as a result of overstepping associated with meltwater pulses of the MIS 2 termination. The MIS 1 sediment wedge comprises reworked sediment and is best developed on the inner shelf. Holocene highstand sedimentation continues to prograde. Accommodation space for coastal deposits is controlled by antecedent drainage pathways and the gradient of the adjacent inner continental shelf. The geological deposits on the emergent shelf indicate a greatly expanded glacial coastal plain that potentially received more rain feeding low-gradient meandering rivers and wetland lakes. These extensive wetland environments provided a rich source of diverse food types which along with abundant marine resources on the shoreline made the Southern Coastal Plain an ideal habitat for our ancestors.

Melissa S. Chapot

Testing the maximum limit of quartz luminescence dating at Luochuan, China

January 2015

Aberystwyth University, Wales, United Kingdom

Degree: Ph.D.

Supervisors: Helen M. Roberts and Geoff A. T. Duller

This study investigates the maximum age limit of quartz luminescence dating, which assesses the time since the last exposure of quartz grains to sunlight. The maximum age range of this technique has been difficult to define because the limiting factors are sample dependent, and difficult to assess due to the dearth of independent age control comparisons for samples older than 50 ka. This study proposes a new concept for testing the maximum limit by comparing natural and laboratory measurements. Twenty-two samples of wind-blown dust (loess) from the Luochuan section of the Chinese Loess Plateau were analysed using two different luminescence signals: optically stimulated luminescence (OSL) and thermally transferred OSL (TT-OSL).

Expected ages for the samples were calculated using an age-depth model based primarily on correlations of palaeosol/loess boundaries with marine isotope stages. This framework of independent age control was transformed into sample-specific estimates of the radiation energy absorbed

in nature (palaeodose) using sample-specific environmental dose rates. Natural dose response curves were then constructed by plotting natural luminescence signals from samples of different ages against their expected palaeodoses. Maximum limits of OSL and TT-OSL techniques were tested by comparing their natural dose response curves with luminescence signals measured after irradiation in the laboratory (laboratory dose response curves).

Optimal measurement conditions for each of the two signals were investigated including signal definition, pre-heat treatments, test dose magnitudes (for the OSL signal), and pulsed-irradiation procedures (for the TT-OSL signal). The results suggest that the current maximum limit of quartz luminescence dating is circa 150 Gy, but that either the OSL or TT-OSL signal may provide the oldest reliable ages depending on the sample specific-signal characteristics. A newly proposed reliability threshold based on the luminescence signal of a naturally saturated sample is suggested to be a more appropriate maximum limit than $2D_0$ for samples of unknown age.

Margret C. Fuchs

Surface processes in response to tectonic and climatic forcing in the Pamir

October 2014

Helmholtz-Zentrum Dresden-Rossendorf, Helmholtz Institute
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Degree: Dr. rer. nat. (Ph.D.)

*Supervisors: Matthias Krbetschek, Richard Gloaguen,
Frank Preusser, Andreas Lang*

The interplay between topographic, tectonic, and climatic factors has fundamental relevance for understanding the mechanisms of mountain evolution and their susceptibility to changes. This thesis combines geomorphometric analyses with geochronological techniques to determine the rates of surface processes in the Pamir. Influenced by the Westerlies and the Indian Summer Monsoon, the Pamir provides ideal conditions to explore the surface process response to climate, and to compare such results with those found in other actively deforming mountains. This thesis addresses four main issues – (1) the distribution of tectonic and climatic factors in the Pamir, and their effects on geomorphometry; (2) the challenge of accurate sediment dating for precise process rates in high mountains; (3) the variability of fluvial incision and its implications for the evolution of the Pamir river network; and (4) which factors control erosion, and how erosion rates relate to local lowering of base levels.

Chapter 2.2 discusses how the collinearity of the major tectonic structures and mountain ranges exert long-term control on flow orientation and local base levels. Due to the dry climate on the Pamir Plateau, fluvial activity is low, and glacial processes are restricted to high altitudes. High topographic variability at the Pamir margins coincide with both,

neotectonic activity along orogenic bounding faults and orographic precipitation from the Westerlies. The trunk stream, the Panj River, indicates major re-organizations of the river network. Successive river captures across the Pamir domes suggest dominant structural control accompanied by possible re-activation of dome bounding faults.

Luminescence dating is of paramount importance for decoding the sedimentation histories, but material from high mountains is challenging due to differential bleaching histories and postdepositional sediment mixing. To address this, Chapter 3.2 describes a transparent, reproducible analysis routine in three data processing templates using the R package ‘Luminescence’. The challenges posed by properties of high mountain materials are addressed in Chapter 3.3, comparing multiple grain and single grain techniques applied to quartz, K-feldspar and plagioclase. These methods allow us to identify prominent events in sediment deposition without interference from bleaching and sediment mixing, or signal loss due to anomalous fading.

Chapter 4.2 applies optically stimulated luminescence (OSL) methods to quantify the variations in fluvial incision along the Panj River. Paleo-glaciations during Marine Isotope Stage (MIS) 2 and MIS 1/2 may have triggered the deposition of terrace sediments, but the rate of incision is primarily consistent with terrace location, rather than time of formation. Where the Panj cuts across the Shakh dara Dome in the southern Pamir, high incision rates of 7 - 10 mm/yr indicate intense river adjustment. Lower incision rates of 2 - 4 mm/yr are consistent with more graded profile sections of the Panj parallel to southern dome boundaries. To the north-east, the Panj incision reflects transient conditions - only the increased incision of 6 mm/yr marks the river response across the Darvaz Fault Zone. These data highlight the structural control of sudden base level drop due to successive river captures, while climatic factors - as well as rock erodibility and drainage architecture - are of secondary importance.

Chapter 5.2 complements the indications from geomorphometry and fluvial incision with cosmogenic nuclide (CN)-based basin-wide erosion rates. Results suggest a rapid average topographic evolution in the Pamir. However, the pace of erosion at the Pamir Plateau shows a strong contrast to the Pamir margins. High erosion rates of 0.55 - 1.43 mm/yr integrate over millennial scale conditions at the western Pamir margin, whereas lower rates of 0.05 - 0.17 mm/yr at the Pamir Plateau also integrate effects of the MIS 1/2 deglaciation. The correlation of erosion with steep slopes (R_2 of 0.82) defines the precondition for high rates in the Pamir. The influence of precipitation only becomes evident in multiple linear regression analyses, explaining erosion as a function of slope and precipitation (R_2 of 0.93). The almost ten-fold discrepancy between fluvial incision rates along the Panj River and basin-wide erosion rates reflects the transience of the landscape with the Panj incising faster than hillslopes adjust. The rate of adjustment increases where the Westerlies supply moisture during winter. This suggests that an efficient sediment transport relates to seasonal peak discharge during the melting season.

The methods and results described, highlight the dominance of tectonic structures in controlling surface processes. In contrast to the southern escarpment of the Himalayas where the Indian Summer Monsoon provides intensive rainfalls, precipitation in the Pamir is limited and hence, works as a restricting factor for hillslope adjustment to fluvial incision. Major reorganisations of the Pamir River network highlight river captures as an important trigger of high surface response rates due to the sudden drop in base levels.

A PDF of this thesis can be downloaded from *Ancient TL*.

Vinícius Ribau Mendes

Santa Catarina coastal dunefields chronology and sedimentology

May 2012

Institute of Geosciences University of São Paulo, São Paulo, Brazil

Degree: Master

Supervisors: Paulo César Fonseca Giannini

This thesis refers to five areas with active and stabilized eolian dune fields in the central coast of the Santa Catarina State, southern Brazil. In this region, a recent tendency to stabilization of active dune fields is inferred from the comparison between aerial photographs of different years. Meteorological data obtained between 1962 and 2010, including daily records of rainfall, wind intensity and wind direction, indicate increasing precipitation and weakening wind to this period. The combination of these two factors inhibits the eolian sediment transport to the dune field, as effect of increasing sand cohesion by wetting and plant colonization in deflation zones. Being persistent in the last three decades, these factors have reduced gradually the sand areas exposed to eolian reworking and decreased more and more the effective eolian drift, culminating in the stabilization of dune fields.

The sedimentary deposits of eolian dunes and paleodunes were grouped, by morphological, stratigraphic, granulometric and mineralogical criteria in four generations (G1 to G4), analogous to that previously recognized in the literature. The older generation (G1) has a wider age distribution than previously thought and can be subdivided regarding the geochronological aspect. The grain-size analysis data indicate trends of sediment coarsening, better sorting and more positive skewness, from the older to the younger generation, what is attributed to the influence of successive reworking of sediments between generations, without discarding the effect of changes in the transport energy and/or beach morphodynamics. The ages of the three older generations obtained by optically stimulated luminescence (OSL) method show coincidence with contexts of stable coastline and with climate in transition from less to more wet.

The observed relationship between the OSL ages, relative sea level (RSL) and paleoprecipitation curves, besides

the model of recent dune stabilization (by the wet increasing and wind energy decreasing), allow us to suggest that the initiation of the dune fields in their different generations, in this coastal region, can be favored by moments of stable and / or in reversal trend RSL, as well by less humid and more windy weather. In other hand, the stabilization of the dune fields would be favored by higher RSL, increasing rain and decreasing wind intensity. From the perspective of climate control, the mentioned condition to initiation of dune fields agree with moments of weakening of the South America Summer Monsoon System (SASM), related to warmer periods in the northern hemisphere. Analogously, the favorable condition for the stabilization of dune fields would coincide with moments of intensification of the SASM, related to colder periods in the northern hemisphere.

A PDF of this thesis can be downloaded from:

<http://www.teses.usp.br/teses/disponiveis/44/44141/tde-27022013-144047/pt-br.php>

Ferdinand Messens

Luminescence dating of tsunami sand in south central Chile a feasibility study

June 2014

Department Geology and Soil Science, Ghent University, Ghent, Belgium

Degree: Master

Supervisors: Dimitri Vandenberghe, Marc De Batist, Philipp Kempf

This work presents an explorative study into the potential of luminescence dating techniques for application to tsunami-laid sands in south-central Chile. The investigated sediments come from a core that was taken in the coastal Lake Huelde; the sequence was about 5 m long and comprised six sandy layers interpreted as being deposited by tsunami events. In the frame of this work, four of these layers were examined using luminescence methods.

The luminescence investigations initially focussed on quartz. However, no pure quartz could be extracted from the samples. The luminescence characteristics of the separates were therefore investigated using a double-SAR protocol, which uses stimulation with IR light prior to the OSL-measurement to minimize the contribution from feldspar. The post-IR OSL signals were dim, not dominated by a fast component, and behaved very poorly in the SAR protocol (as indicated by the SAR procedural tests: recuperation, recycling ratio and dose recovery). Microscopic observations using thin sections were used to relate this luminescence behaviour to the mineralogical composition and provenance of the sediments. It is concluded that OSL signals from quartz are not suitable for dating these tsunami-laid sands.

The investigations were therefore directed towards an alternative dosimeter, K-feldspar. Stimulation was with IR at 50°C (IR50) and the luminescence characteristics of this signal were investigated using a SAR protocol. All samples

emitted bright IRSL signals that behaved well in the SAR protocol in terms of recycling and recuperation. The dependence of equivalent dose, anomalous fading and fading-corrected age on preheat temperature was examined for two samples. It is concluded that a low preheat temperature of 60 s at 80°C is required to minimize significant age overestimation owing to thermal transfer. In line with earlier finds, we find no evidence that higher preheat temperatures isolate a signal that is thermally more stable. The distribution of equivalent dose, fading rate and fading-corrected age was then examined in each of the four samples. Broad distributions were observed for all samples. Apart from a few outlying values, the corrected age distributions in the two lowermost samples appear to belong to a single population. The spread observed in these samples (RSD: 20 %) was therefore taken as a measure for the spread that can be expected for a well-bleached, undisturbed and unmixed sample. The distributions obtained for the two uppermost samples are clearly asymmetric, with values extending over a wider and higher age range. Using our estimate of the spread that can be expected in the ideal situation, the population with the lowest corrected ages was isolated from these distributions; these values are more likely to approximate the depositional age of the sediments. The fading-corrected IR50-ages are broadly consistent with the stratigraphic position of the samples and range from 0.174 ka to 1.64 ka. Interestingly, a slight age inversion was observed for the two lowermost samples; it remains to be established whether this relates to an underestimation of the uncertainties, dosimetric issues (e.g. related to the non-uniformity in the radioactive surroundings of the samples) and/or the specific nature of the erosion and transport process. Following the investigations using IR50, we also briefly examined the potential of a post-IR IRSL signal, which was obtained by stimulating with IR at 290°C following a stimulation with IR at 50°C (pIRIR290); this approach has been shown to circumvent any correction for anomalous fading. The pIRIR290-signal behaves well in the SAR protocol, and laboratory measurements of signal stability confirm the earlier finds with respect to anomalous fading. The pIRIR290-ages overestimate the IR50-ages by 6 ka, which may be due to thermal transfer and/or incomplete resetting. It is concluded that, despite its attractive dosimetric properties, the pIRIR290 signal is unlikely to be applicable to Holocene deposits. In general, it is concluded that IR50-signals from K-feldspar provide a powerful means for establishing chronologies for tsunami-laid sands in this region. This conclusion is corroborated through a comparison of the IR50-ages with the available independent age information (such as historical records and ¹⁴C-dating of comparable sequences in the study region). The study also provides the first evidence for a tsunami triggered by the 1837 AD seismic event. Finally, our study also demonstrates the importance of direct numerical age information for tsunami-laid sands to correlate palaeoseismological records derived from cores that were taken in the same sediment archive (i.e. Lago Huelde).

A PDF of this thesis can be downloaded from:

http://lib.ugent.be/fulltxt/RUG01/002/163/647/RUG01-002163647_2014_0001_AC.pdf

Fabiano do Nascimento Pupim

Geomorphology and paleo-hydrology of the Cuiabá and São Lourenço fluvial megafans, Quaternary of Pantanal (Geomorfologia e paleo-hidrologia dos megaleques dos rios Cuiabá e São Lourenço, Quaternário da Bacia do Pantanal)

September 2014

Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista, Rio Claro - SP, Brazil

Degree: D.Sc.

Supervisor: Mario Luis Assine

The Upper Paraguay River Basin comprises three areas with remarkable differences regarding their physical and biological aspects: plateaus, erosional lowlands and the Pantanal plain. The Pantanal is the world's largest freshwater wetland and is characterized as a complex depositional system tract fed by fluvial megafans. The origin of these large depositional landforms is related to the tectonic setting and basin subsidence; however the Late Quaternary dynamic has been mainly influenced by climate change and interactions with the surrounding erosional terrains. Considering the peculiarities and environmental importance of the area, the main aim of this study was to investigate aspects of the Late Quaternary evolution of fluvial megafans formed by the Cuiabá and São Lourenço rivers in the northern portion of the Pantanal, as well as the degradational systems of the Cuiabana lowlands in the source area. Remote sensing, geomorphological, facies analysis and geochronological data were used to achieve these goals. Satellite images and digital elevation models were used to unveil contrasting channel patterns and distinguish geomorphic zones. Optically stimulated luminescence dating (OSL) allowed to establish a chronology and to reconstruct the chain of main events that shaped the megafans. The depositional systems formed by Cuiabá and São Lourenço rivers are, respectively, the second and the third biggest fluvial megafans in the Pantanal, exhibiting fan shaped morphology, low topographic gradient and unconfined flow to downstream. Three different fluvial channel styles were recognized, reflecting distinct phases of aggradation and incision during the Late Quaternary. Distributary braided paleochannels preserved on the surface of Pleistocene lobes record semi-arid climate conditions and scarce vegetation, and a period of high aggradation during the Late Glacial. The Pleistocene lobes have been dissected by small streams radiating from the fan apex and the rain waters tend to produce widespread sheet flows, reworking the surficial sediments. No OSL ages were found between the Late LGM and the Holocene, indicating very low and localized sedimentation, and a period of fluvial incision in the upper fan settings; truncate ancient lobes' surface and create the incised valleys. The incised valleys were

mainly filled by Early and Middle Holocene-aged meander belt deposits, which consist of very fine sands interbedded with fine-grained deposits. Currently, the incised valley is a zone of sediment bypass and works as a feeder channel of the distal distributary sinuous channels. The distal lobes are the modern depositional site, formed by progradation of avulsion belts into a broad floodbasin. The Holocene avulsions are random. The timescale of regional avulsion (lobe changes) are around thousands of years, whereas the local avulsions (bifurcation in small channels) take less than ten years. The paleo-hydrological changes (braided-incision-meandering) observed in both systems were mainly controlled by Late Quaternary climatic fluctuations, being an example of tropical and subtropical river response to global climate changes. Cosmogenic nuclide analysis (^{10}Be) enabled the determination of erosion rates and exposure ages in the Cuiabana lowlands. The relief denudation has been driven by differential erosion and strong lithological control. The laterization of the deposits rich in quartzite clasts appears to be a key factor maintaining hilltop summits of the planation surface over long timescales. Clastic-lateritic deposits have slow erosion rates, similar to the world's slowest, preserving an ancient surface planation whose minimum age is Middle Pleistocene.

Keywords: fluvial megafans; channel patterns; Cuiabana lowlands; cosmogenic nuclides; OSL dating.

Eren Şahiner

TL/OSL And ESR Methods Used in Paleoseismology Studies: Kütahya-Simav and North Anatolian Fault Zone

April 2015

Ankara University, Graduate School of Natural and Applied Sciences, Department of Engineering Physics

Degree: Ph. D.

Supervisors: Niyazi Meriç

Thermoluminescence (TL), Optically Stimulated Luminescence (OSL) and Electron Spin Resonance (ESR) techniques stand among the basic research tools in the fields of (a) ionizing radiation dosimetry, (b) archaeological and geological dating and retrospective dosimetry, (c) authenticity testing of archaeological artifacts. Dating by applying these methods is based on the measurement of trapped electronic charges that are accumulated in crystalline materials as a result of low-level natural radioactivity present at sites, which help to calculate the time since the traps were empty. For TL and OSL, the population of trapped charges is measured by the amount of light emitted by electrons released from their traps via heat and light, correspondingly. Electrons are not evicted by ESR spectrometry; the strength of the signal emitted by trapped electrons provides a measure of the population size.

The present study examined the feasibility of using TL/OSL and ESR techniques for paleoseismological studies

in order to date fault gouges traces from Anatolia. The basic effort was towards examining the validity of basic assumptions on luminescence dating technique using samples with age constraints. The aim and scope of the thesis can be summarized in two broad categories, including methodological aspects and feasibility of dating. In this process, new protocols were developed, tested and applied, including multiple, independent equivalent dose estimation approaches which were adopted, using both luminescence and ESR techniques; de-convolution approximations as well as Thermally Assisted OSL, TA-OSL, stimulation with simultaneous heating of the Very Deep Traps (VDT) were applied towards possible extension of age limit in luminescence dating applications. According to the results yielded, in some special conditions age limits could be extended over one order of magnitude using TA-OSL after stimulating VDT in the natural minerals. Furthermore, one approach is succeeded in order to improve the understanding of the trapped electron recombination lifetime in the crystal structure. Finally, it was established that Infrared stimulated luminescence (IRSL) of samples of mixed mineralogy at elevated temperatures stimulates quartz mineral as well.

This study therefore provides a basis for the application of trapped charge dating methods and concludes that it can play a significant role in studies related to trap-charge dating researches and luminescence mechanisms in the crystal structures.

Keywords: Thermoluminescence (TL), optically stimulated luminescence (OSL), electron spin resonance (ESR), de-convolution, Very Deep Traps (VDT), Thermally Assisted OSL (TA-OSL), paleoseismology, luminescence dating, ESR dating, fault gouges, PostIR-OSL, SAR, equivalent dose, annual dose.

Qingfeng Shao

Combined ESR/U-series Dating of Fossil Teeth from Middle Pleistocene Sites in Northern Europe and Mediterranean Area: Contributing to the Chronology of the Acheulian Settlements of Europe

2011

Muséum National d'Histoire Naturelle; Département de Préhistoire

Degree: Ph.D.

Supervisors: Jean-Jacques Bahain, Christophe Falguères

Combined ESR/U-series dating of fossil teeth has been increasingly used in geochronological research over the past two decades. Results prove that it can be potentially applied to sites in different geological contexts (fluvial/lacustrine or karstic environments) over a timescale of $10^4 - 10^6$ years, and it is an interesting dating method for studies of the Pleistocene human migrations, such as the dispersal of Acheulian bifacial technology.

The present work mainly contains 1) a detailed study of the combined ESR/U-series dating theory for understand-

ing its limitations; 2) the development of an age calculation software ESRUSAGE with Monte Carlo simulation for age and age error estimation; 3) the creation of a new U-uptake model named AU model, which allows age calculations for teeth that probably experienced U-leaching; and geochronological applications to four major archaeological sites: 4) Mauer, Germany, eponym locality of discovery of the Mauer mandible, holotype of the *Homo heidelbergensis* species; 5) Isernia la Pineta, Italy, allowing a comparative study with $^{40}\text{Ar}/^{39}\text{Ar}$ dating; 6) Thomas Quarry 1 Hominid Cave, Morocco, Acheulian site previously dated by OSL dating of quartz and LA-MC-ICP-MS on hominin tooth; and 7) Qesem Cave, Israel, allowing a comparison with TL dating of heated flints and $^{230}\text{Th}/^{234}\text{U}$ dating of speleothems.

These applications demonstrate that the newly developed ESRUSAGE program and AU model really improve the applicability of combined ESR/U-series dating approach. Comparative studies show that this approach can be successfully used to Middle Pleistocene caves and open air sites, but can be limited by geological dosimetric changes. The age estimates obtained in the present work on the four Acheulian related sites support the general consensus that the first appearance of Acheulian in Europe is probably not before 700 - 600 ka.

Keywords: ESR/U-series dating method; Early Middle Pleistocene; Acheulian settlement; U-uptake and leaching; Mauer; Isernia la Pineta; Thomas Quarry 1; Qesem Cave