Ancient TL

Thesis Abstracts

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Catherine Elizabeth Buckland
New methods for identifying dune system reactivation drivers and responses, Nebraska Sandhills

January 2019

School of Geography and the Environment, University of Oxford, South Parks Road, Oxford

Degree: Ph.D.
Supervisors: David Thomas, Richard Bailey

Two billion people living in drylands are affected by land degradation and the destabilisation of surface sediments. However, a detailed understanding of the combined effects of natural and anthropogenic factors in contributing to sediment remobilisation is absent from the literature. A quantified awareness of vegetation cover sensitivities and resultant land degradation to forcing factors is needed if the vegetation and landscape response to future climatic changes and human pressure are to be better predicted.

Measuring past environmental response in a location with a known disturbance history allows us to identify thresholds and explore the relationship between disturbance forces and sedimentary response within a dryland environment. The Nebraska Sandhills, located in the Central Great Plains, is a semi-arid dune field with a reactivation history spanning the last 10,000 years and a well-documented history of forcing factors over recent decades. Whilst regional reactivations in the Central Great Plains have largely been attributed to palaeoclimatic change, the role of humans (e.g. The Dust Bowl of the 1930s), in particular over grazing, has also been cited as a potential cause of land degradation and sediment reactivation.

Using quartz luminescence dating, secondary datasets of forcing factors and statistical inference methods, this thesis identifies the record of sediment deposition in near-surface aeolian stratigraphies in the northern remits of the Nebraska Sandhills and explores the relationship between environmental sensitivity and external disturbance factors. High-resolution luminescence techniques allow us to construct a detailed chronological history of sedimentary deposition events over the last 900 years, producing a record of the environmental response across a range of aeolian features within the semi-arid setting. Combined with a detailed history of climatic, grazing and wildfire pressures, supervised machine learning techniques explore the relationship between forcing factor and environmental response, highlighting the importance of both regional and localised conditions in contributing to the heterogeneous sedimentary response found in the record.

A PDF of this thesis can be downloaded from:

Laura Eddey
The Late Quaternary Palaeoenvironment of the Vale of Pickering

December 2018

University of Sheffield, Sheffield, United Kingdom

Degree: Ph.D.
Supervisors: Mark Bateman, Stephen Livingstone, Jon Lee

During the Quaternary, repeated glacial cycles left widespread deposits across Britain. These deposits hold an archive of terrestrial responses to changes in climate over the last 2.6 Ma. One such archive is the Vale of Pickering in North Yorkshire: A low-lying depression bounded on all sides save the east end by large hills comprised of Jurassic and Cretaceous bedrock. During the Late Quaternary, this natural basin was blocked by ice sheets forming large proglacial lakes. To understand the advance and retreat of the surrounding ice lobes in the Vale of York to the west and the North Sea Lobe to the east – the deposits of the Vale of Pickering are crucial; however, limited work in the area has failed to ascertain an accurate history of Lake Pickering. Using newly available high-resolution LiDAR data, field observations, historic borehole records, and optically stimulated luminescence (OSL) dating, a new chronological model for Lake Pickering has been established. This shows that 1) previously estimated lake levels are too high and that during the LGM, Lake Pickering was no more than 33 m O.D. 2) Ice invaded the eastern coast of the Vale of Pickering on more than one occasion, potentially earlier than the LGM. 3) Several iterations of Lake Pickering exist with a lake during the LGM, but at least one older than 30 ka. 4) The drainage of Lake Pickering is very complex and seaward drainage likely prevailed until the eastern end became blocked by continued deposition of glacial material. This reversed the drainage through the Kirkham Gorge. 5) The use of newer geoscientific techniques like OSL and LiDAR mapping are crucial to the understanding of the palaeoenvironment of the Vale of

Pickering and the continued development of these techniques are vital to further work.

Geraint Jenkins
Development and application of luminescence dating of cobbles from glaciofluvial sediments

January 2019
Department for Geography and Earth Sciences, Aberystwyth University, Wales

Degree: Ph.D.
Supervisors: Department for Geography and Earth Sciences, Aberystwyth University, Wales

The aim of this thesis is to develop and test the luminescence dating of cobbles from glaciofluvial sediments. In recent years luminescence dating has increasingly been applied to date glaciofluvial sediments, but uncertainties about the degree of bleaching of the luminescence signal make dating challenging. Sub-surface luminescence measurements from cobbles from well-bleached environments are able to confirm that the cobbles were well-bleached at deposition. Having this confirmation when studying heterogeneously bleached environments would be a significant advantage.

Bleaching experiments are undertaken to assess if numerical models of bleaching with depth are correct in nature. Measurements confirm that as the length of exposure increases the luminescence signal is reset to greater depths. Cobbles obtained from Orrisdale Head, Isle of Man, show significant sub-surface bleaching, with rock slices to depths of 12 mm into the cobble sub-surface having been completely bleached at deposition. Fading-corrected IRSL50 ages (20.7 ± 1.3 ka) agree with independent age control at the site. One cobble also appears to show both the advance (26.2 ± 0.3 ka) and retreat of the Irish Sea Ice Stream. A major advantage of applying luminescence dating to cobbles instead of sand-sized grains is that at depths of > 2 mm into the cobble 92% of the dose rate comes from the cobble itself and this makes luminescence ages insensitive to water content.

In further tests of this approach, cobbles from two locations in north Wales show limited sub-surface bleaching, however the IRSL50 ages from the surface slices agree with independent age control. Following the trial at locations with independent age control, cobbles are obtained from a deposit at Bridgwalton which marks the furthest extent of a separate ice lobe which occupied the Cheshire-Shropshire basin. The IRSL50 age (25.3 ± 1.6 ka) gives the first depositional age for this location and shows that the Last Glacial Maximum (LGM) at this site is synchronous with that observed for the Irish Sea ice stream at the Scilly Isles. Luminescence dating of cobbles has an enormous potential in providing accurate and robust ages for glaciofluvial sediments that are challenging to date.
A copy of the thesis can be given at request to: gej11@aber.ac.uk

Miao Li
Study on thermal activation characteristics of the ESR signal intensity of moraine quartz E_1' center

May 2019
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Degree: M.Sc.
Supervisor: Chaolu Yi

The quartz E_1' center is a paramagnetic defect center, and the maximum value of the ESR signal intensity of the E_1' center in its thermal activation has been applied for dating of sediments and determination of sediment sources. However, there are still different views on the method for obtaining the maximum value of the thermal activation ESR signal intensity of the E_1' center, such as whether artificial irradiation is needed before heating, whether there is a difference in the optimum thermal activation of temperature and time of the E_1' center, and it needs further study. In addition, there has been no report on the study of moraine provenance by using the ESR signal intensity of the quartz E_1' center at present.

In order to clarify the method of obtaining the maximum value of the thermal activation intensity of the E_1' center and to provide basic experimental data and theoretical references for practical application, the thermal activation characteristics of the ESR signal intensity of moraine quartz E_1' center was studied by using artificial gamma irradiation, thermal annealing and ESR signal measurement. Moreover, in order to provide a simple and fast new method for identifying the provenance of plateau moraines, the provenance of moraines on the west side of the Purog Kangri ice field in the inner Tibet was identified by using the natural signal intensity of the quartz E_1' center, the maximum value of the thermal activation intensity of the E_1' center and the quartz crystallinity index (CI).

The specific conclusions are as follows:

(1) At room temperature and in the range of $\lesssim 2500$ Gy of artificial irradiation, the ESR signal intensity of the E_1' center increases with the increase of irradiation dose due to the formation of the counterfeit E_1' center, while the signal intensity of the E_1' center decreases with the increase of irradiation dose likely due to the decay of the real E_1' center caused by the gamma ray irradiation.

(2) The optimal temperature (peak temperature) of thermal activation for the E_1' center ESR signal intensity in the quartz from the moraines collected in the West Kunlun Mountain and the Purog Kangri is approximately $300\,^\circ$C. When the heating temperature was lower than the peak temperature, the signal intensity of the E_1' center increased with the increase of heating time; otherwise, the E_1' center signal intensity decreased.

(3) At the peak temperature, there was a range of the thermal activation time, (or the optimal activation time range) at which the E_1' center signal intensity reached its maximum value. When the activation time exceeded this range, the ESR signal intensity of the E_1' center decreased.

(4) There is a correlation between the ESR signal intensity of the E_1' center and artificial irradiation dose when the E_1' center is in the growth stage; when the E_1' center decays, it is less correlated with irradiation dose.

(5) The maximum ESR signal intensity of the thermal activation of the E_1' center in the quartz samples both from West Kunlun Mountain and Purog Kangri increased first with the increase of artificial irradiation dose, and then saturated above 400 Gy, indicating that artificial irradiation is needed in order to obtain the maximum ESR signal intensity of the thermal activation of the E_1' center.

(6) The natural signal intensity of the quartz E_1' center, the thermal activation peak intensity of the E_1' center and the quartz crystallinity index (CI) indicate that $73\% - 93\%$ of the moraine sediment furthest away from the west side of the Purog Kangri ice field came from the north side and only $7\% - 27\%$ from the east side.

(7) The natural signal intensity and the maximum value of the thermal activation ESR signal intensity of the quartz E_1' center and the quartz crystallinity index (CI) can both provide effective guidance for identification of provenance for moraine, and the ESR technology is suitable for the study of the provenance of plateau moraines.

A PDF of this thesis can be downloaded from: Chinese Academy of Sciences Dissertation Database.

Ian del Río
Técnicas de datación por luminiscencia en el norte de Chile: implicación para la evolución tectónica y geomorfológica de la Península de Mejillones durante el Cuaternario
(Luminescence dating in northern Chile: Implications for the Quaternary tectonic and geomorphologic evolution of the Mejillones Peninsula)

May 2019

Departamento de Ciencias Geológicas, Universidad Católica del Norte, Antofagasta, Chile

Degree: Ph.D.
Supervisors: Gabriel González, André Oliveira Sawakuchi

The geomorphology of the Mejillones Peninsula, northern Chile, evidences a Quaternary tectonic uplifting process. Upper plate faults located close to the peninsula show recent activity. However, there is no consensus about the uplift rate of the Mejillones Peninsula in the millennial timescale and numeric ages of uplifted sediments or sediments related to fault activity are scarce. These geochronological data is crucial to establishing the geologic history of the upper plate faults and to improving the understanding on plate tectonics processes in Chile. The main aim of this Ph.D. thesis is to contribute to a better knowledge of the subduction process and upper plate deformation relationship through the quantification of the coastal uplift and the upper plate fault activity in the Mejillones Peninsula for the Late Quaternary applying luminescence dating techniques to quartz and potassium feldspar. To achieve this, 31 sediment samples were collected from four localities: marine-coastal sediments from the Pampa Mejillones, an alluvial deposit associated to the Mejillones Fault, alluvial and eolian deposits associated to the Naguayán Fault and a colluvial deposit associated to the Salar del Carmen Fault. Topographic profiles from the Mejillones Peninsula and the studied faults were obtained by means of a differential GPS. Trenches were excavated in the fault traces for paleoseismic analysis and their fault scarps were modelled with high-resolution 3D techniques.

Optically stimulated luminescence (OSL) signals from quartz and post-infrared infrared stimulated luminescence (pIRIR) signals from K-feldspar were analyzed to determine sediment burial ages. From the comparison between OSL and pIRIR ages, it was concluded that the OSL ages from quartz are largely underestimated. This is attributed to the fact that the quartz OSL signals lack a strong fast OSL component and that predominant medium and slow components show thermal instability. On the other hand, pIRIR signals are close to stability, showing low, though variable, fading rates ($0.7 - 6.77\%$/decade), and bleachable, presenting low residual doses in modern analogues (between 2 and 6 Gy). The alluvial sediments spatially associated with the Mejillones Fault yielded fading-corrected pIRIR ages between 87.4 ± 6.6 and 163.4 ± 18.4 ka. For the sediments associated with the Naguayán fault, the fading-corrected pIRIR ages were between 10.4 ± 1.3 and 44.1 ± 4.7 ka. The fading-corrected pIRIR ages of the colluvial sediments associated with the Salar del Carmen Fault resulted between 14.7 ± 1.0 and 131.6 ± 74.2 ka. For the coastal sediments from the Mejillones Pampa, fading-corrected pIRIR ages were from 70.6 ± 5.1 to > 330 ka.

From the paleosismological study of the Naguayán and Salar del Carmen Faults, it is concluded that the activity of these faults has been continued during the Late Pleistocene and Holocene. The activity rates of both faults classify them as slow faults, with slip rates of ~ 0.06 m/ka and earthquakes recurrences of 20 ka. Based on stratigraphic references such as colluvial wedges, it was possible to estimate coseismic displacements of up to 2 m, translating into magnitudes of paleoearthquakes of up to Mw7.2. In the specific case of the Naguayán Fault, at least four events could be identified, two of which occurred less than 40 ka ago. According to the pIRIR ages obtained for the studied sediments, Pampa Mejillones has uplifted at rates ranging from 0.25 to 0.5 m/ka between 400 and 100 ka. For the last 70 ka, the pIRIR age obtained in a coastal marine deposit suggests an uplift acceleration to 1.01 m/ka. The activity of the Mejillones Fault, estimated in 0.26 m/ka, partially controls the disposition, formation and preservation of the paleocoastlines, in combination with the variation of relative sea level. Based on these data, an evolution model of the Mejillones Peninsula during the Late Pleistocene is proposed according to which the coastal deposits found in the Pampa Mejillones record coast-

line progradation and retrogradation as a consequence of the combination of tectonic uplift, eustatic sea level variation and upper plate fault activity. An excess in the uplift rate over the subsidence produced by the activity of the Mejillones Fault would elevate the Pampa Mejillones surface, generating the current coastal cliff. Therefore, coastal uplifting process and the upper plate fault activity, especially the potential reactivation of Mejillones and Naguayán faults, must be considered as a potential seismic hazard to the urban and productive infrastructure of Mejillones and industrial complexes located in the Coastal Cordillera.

A PDF of this thesis can be requested from the author at idelrio@alumnos.ucn.cl.