Thesis Abstracts

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Saltmarsh Resilience in a Changing Climate: Geomorphological and Biological Processes in Natural and Managed Salt Marshes in the North East of Scotland

August 2023

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Degree: Ph.D.

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Salt marshes are regarded as one of the world's most productive ecosystems due to the unique habitat they provide, which is essential to our ecological structure, and their ability to act as sinks for organic and inorganic sediment. Salt marshes have long attracted human settlement and exploitation due to their location along the coast, on the sheltered shores typical of estuaries and tidal inlets. The permanent loss of saltmarsh ecosystems is between 25 and 50 percent of their global historical coverage, and the decline continues globally. This is exacerbated by rising temperatures, sea level rise, and increasing storm intensity, which erode salt marshes. Since 1945, roughly 15 percent of saltmarsh area in the United Kingdom has been lost due to human intervention, primarily agricultural and industrial reclamation, and is now being exacerbated by coastal erosion and sea level rise. Saltmarsh formation and development are influenced by the interdependence of physical and biological processes, whereas vertical growth and saltmarsh stability are highly dependent on sediment supply and tidal range. However, the cumulative impact of human disturbance and sea level rise on the fundamental saltmarsh dynamics remains unclear and must be better understood at both the local and global scales.

This thesis aimed to improve understanding of the processes, mechanisms and patterns that 1) favour saltmarsh formation and development 2) enable saltmarsh capacity to recover from environment and anthropological disturbances 3) promote some of the regulating and supporting services salt marshes provide. My thesis has carried out a biogeomorphological appraisal of the first salt marsh managed realignment in Scotland since its breaching in 2003 in comparison with two adjacent natural salt marshes across different time scales. The study has employed a methodology to assess jointly managed/anthropogenically modified and natural salt marshes at different temporal scales. A set of managed and adjacent natural salt marshes within the same salt marsh system at Nigg Bay, NE Scotland provided a comparative case study of the links between sediment availability, vegetation presence and saltmarsh stability over time and space. Above ground changes in vegetation and sedimentation patterns were quantified over different timescales from short (annual) to longer (centennial) timescale using a combination of field measurements: sediment deposition, sedimentation plates and DEM time series in tandem with vegetation sampling. This multi-method approach has proven to be a powerful tool to analyse spatial distribution patterns of sediment accretion. Below ground physical and biological changes were explored using a combination of traditional sedimentary techniques and applying Luminescence to salt marsh, to gain knowledge on the possible mechanisms driving these changes. These results were used to assess the potential implications on the supporting and regulating benefits that salt marshes provide, as such contributing to saltmarsh blue carbon inventories for natural and managed realignment salt marsh in Scotland; and, on capacity of marshes to keep up with rising sea levels.

The cumulative results of my thesis work highlight that natural salt marshes have limited space to respond to environmental changes, which reduces their long-term resiliency. In terms of sea level rise, the marsh is responding due to the accommodation space provided by the managed realignment.

Furthermore, the study has developed a new application of Optically Stimulated Luminescence (OSL) that challenges the results of conventional techniques and allows exploration of modern sediment material registering the impacts of recent climate change. This work thus adds an important dataset to the Scottish context and more broadly to the growing literature on the ability for managed realignment sites to replicate natural saltmarsh functions and thus ecosystem services.

A PDF of this thesis can be downloaded from: http://theses.gla.ac.uk/id/eprint/83810

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Developments and Applications of Luminescence Dating in Earth Sciences

November 2023

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This thesis aims to address fundamental questions about developments and applications in luminescence dating in the past, present, and future, including the age range, accuracy, and thermochronological studies.

To estimate the equivalent dose (D_e) of calcite, a single-aliquot regenerative-dose (SAR) protocol with low-temperature measurements is employed. It uses the isothermal thermoluminescence (ITL) signals measured at ~ 225 – 240 °C, where a D_e vs. ITL temperature (D_e-T) plateau is observed. These ITL signals correspond to the TL signals of the 280 °C TL peak. Notably, ITL signals at 230 – 235 °C saturate at ~ 4000 – 5000 Gy, which has the potential to date geological and archaeological samples spanning the entire Quaternary period. The absence of detectable anomalous fading of ITL signals suggests that the signal is free of fading. Dose recovery tests further confirm the suitability of the SAR-ITL protocol for D_e estimation.

The SAR-ITL protocol was then employed to study the thermochronological applications of limestone rocks in the middle of the Nujiang River, southeastern Tibetan Plateau. The results show that apparent D_e values of ITL_{230} signals increase with increasing heights, while apparent ages increase before approximately 400 ka (the apparent age) and then reach dynamic equilibrium stages. From the isochron plot of apparent D_e values against dose rates, the effect lifetimes of ITL signals were obtained, which constrains the applicable ranges of ITL signals from calcite. It is proposed that calcite can be used in thermochronology within the applicable ranges from 530 $\pm$ 25 ka to the present.

The accurate luminescence dating of volcanic-related materials remains challenging. This study focuses on quartz minerals extracted from lava-baked sediments in the Tengchong volcanic field, southeastern the Tibetan Plateau, using the optically stimulated luminescence (OSL) technique. The results show that samples with initial OSL signals dominated by the fast component yield reliable ages. Conversely, samples dominated by unstable medium and slow components broadly underestimate their OSL ages, requiring corrections. By using the plot of D_e against recuperation for each aliquot, the underestimated OSL ages can be corrected. The final single-aliquot quartz OSL ages are consistent with single-grain quartz OSL and ^{14}C ages recording the same eruption event, thus validating the reliability of the dating ages.

The comprehensive research on photoluminescence (PL) emission spectra of various feldspar types remains poorly understood and the limited availability of instruments has hindered its research. This study investigated the PL properties of six feldspar types using a commercial Raman instrument. The results indicate that the number and medium positions of emission peaks depend on the specific feldspar types and samples analyzed. Additionally, the sensitivity of PL signals to irradiation dose varies across feldspar types and peak positions. Notably, PL emissions from ~ 865 and ~ 910 nm of K-feldspar are sensitive and show potential applicability for dating applications. The dose-response curves obtained using 860 – 870 nm PL signals of potassium feldspar conform to a relationship of a single saturating exponential function between the signal and irradiation dose. This study demonstrates that a commonly available Raman system can be utilized for PL measurements of single grains.