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NERC SCIENCE OF THE ENVIRONMENT

Glacial History of the Tropical Andes, Peru (Ref IAP-17-93)

Newcastle University, School of Geography, Politics & Sociology

In partnership with SUERC, University of Glasgow and Durham University, Department of Geography

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Key Words	**1. Glacial geomorphology; 2. Cosmogenic isotope dating; 3. Geophysics; 4. Tropical glaciation 5. South America.**

Overview

Elucidating the role of the tropics in global climate change is essential for constraining future climate trajectories. It is now recognised that during the Late Pleistocene, major shifts in tropical temperature and precipitation occurred, and this has challenged the typical view of tropical climate stability during this time.

The geographical and altitudinal extent of modern glaciers in the northern Andes reflects the sensitivity of the cryosphere to climate. Because tropical glaciers are highly sensitive to variations in the tropical hydrological cycle, as determined by changes in atmospheric circulation and regional moisture patterns, they, and the geomorphic signature they leave on the landscape, are useful indicators of both present and past environmental conditions (e.g. Rodbell et al., 2009; Smith et al., 2005, 2008). Despite their importance for understanding past climate in the tropics, little work has been undertaken on the timing and nature of palaeo-glaciological events in the tropical Andes.

This PhD project will target a formerly glaciated region in northern Peru at ~5°S. The student will couple glacial geomorphology, near-surface geophysics and geochronology to build a regional glacial history of the most recent glaciation. The studentship will address the following research questions:

1. What was the local last glacial maximum (LLGM) in northern Peru?
2. Is there evidence for Younger Dryas/Holocene glacial readvances in the tropics of South America?
3. What climate parameters control the initiation and termination of glaciation in the tropics?

Methodology

This multidisciplinary PhD project will blend field and remotely-sensed geomorphic mapping, surface exposure dating using terrestrial cosmogenic radionuclides (TCN), radiocarbon and near-surface

geophysics to investigate the glacial history of northern Peru.

Initially, the student will undertake a desk-based survey of the study region, using remotely-sensed imagery (e.g. LANDSAT, Sentinel-2) and DEMs to identify and map geomorphic landforms (Glasser et al., 2008) associated with previous glaciations in the Cordilleria de Wamani, Northern Peru. Results will be used to reconstruct the regional glacial history, and to design field work activities.

Field expeditions will involve two seasons in northern Peru, in 2019 and 2020. The objective of the first field season is for the student to map geomorphological features, acquire initial samples suitable for cosmogenic radionuclide and radiocarbon analysis, and undertake reconnaissance of field sites using ground-penetrating radar (GPR). A joint geophysical survey (swath bathymetry, seismic sub-bottom profiling, GPR) will be undertaken on lakes and wetlands at the site. These data will be acquired and processed in collaboration with a parallel PhD project, investigating the palaeoenvironmental record from lake sediments. In this project, geophysical results will be used to map lake-bottom and sub-lake and/or sub-peat geomorphology such as glacial landforms (e.g. moraines).

Samples for TCN dating will be acquired from moraines, boulders and/or eroded surfaces during both field seasons. Radiocarbon samples will be acquired from intra-moraine peat deposits. Preparation and analysis of the samples will be undertaken at the Scottish Universities Environmental Research Centre (SUERC). Cosmogenic nuclide and radiocarbon dates will be integrated with geomorphological mapping and geophysical surveys of sediments and landforms, to reconstruct the timing and nature of the most recent glacial and deglacial events in the study area. This observationally-based reconstruction will then be tested against numerical modelling of the environmental conditions required to initiate glaciation and deglaciation in the northern Andes (i.e. through sensitivity testing of regional temperature, precipitation etc.).

Timeline

Year 1:
- Review of existing studies of glacial history from the Andes.
- Regional geomorphic mapping using remotely sensed data.
- Planning and organisation of field expedition 1.
- Field expedition – Season 1 (Jan 2019).
- Preparation of samples from season 1 for cosmogenic nuclide and radiocarbon dating.
- Processing and analysis of geophysical data.

Year 2:
- Interpretation and synthesis of data from remotely-sensed and field-based geomorphic mapping.
- Planning and organisation of field expedition 2.
- Field expedition – Season 2 (Jan 2020).
- Preparation of samples from season 2 for cosmogenic nuclide and radiocarbon dating.
- Begin numerical modelling activities.

Year 3:
- Complete outstanding cosmogenic nuclide and radiocarbon analysis, and establish glacial history of field site.
- Using numerical modelling, assess the environmental conditions necessary to initiate and end glaciation in northern Peru.
- Interpretation and synthesis of data from mapping, dating, geophysics and numerical modelling to reconstruct the most recent glaciation and deglaciation of northern Peru.
- Present results at an international conference.
- Begin write-up of thesis.

Year 4 (six months only):
- Complete write-up of thesis and submit papers.

Intended outputs from the PhD are:
1. A reconstruction of the glacial history of northern Peru over the last ~40,000 years.
2. An evaluation of the environmental conditions necessary to initiate and terminate glaciation in northern Peru.
3. An assessment of the climate parameters that drive (and limit) tropical glaciation.

Training & Skills

The student will be trained in a broad range of geomorphological, geochronological and geophysical techniques. The student will receive bespoke training in field skills (e.g. geomorphic mapping, sampling for cosmogenic nuclide and radiocarbon dating and near-surface geophysics), and laboratory skills in preparing cosmogenic nuclide samples for analysis. In-house training will be provided in geophysical data acquisition and processing, gaining skills in software packages (e.g. Reflexw and Opendtect) and equipment (i.e. ground penetrating radar and seismic reflection). They will also have opportunities to attend NERC-recognised short courses such as 'Integrating Remote Sensing Into Advanced Geomorphological Mapping'

and 'Geophysical Skills Development for Environmental Scientists'.

References & Further Reading

Glasser NF, Jansson KN, Harrison S, Kleman J. (2008). The glacial geomorphology and Pleistocene history of South America between 38°S and 56°S. Quaternary Science Reviews, 27, 365-390.

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Further Information

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