EARTHSCIENCES

Extent, timing, and cause of Quaternary uplift along the Atlantic margin of Morocco

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Key words:	Geohazards, earthquake, coastal terraces, geomorphology, fieldwork, remote-sensing, seismology, paleoseismology, Morocco
Research theme(s):	Geodesy, Tectonics, Volcanology and related hazards
Eligible courses for this project:	DPhil in Earth Sciences (3-4 years) – This project is funded at the UK rate by the Leverhulme Trust

Overview

The destructive 2023 Marrakech (Morocco) earthquake, demonstrated the widespread – and largely unknown - hazard posed to populations, infrastructure, and cultural heritage within the country. The earthquake was surprising, due to its location and size, and highlighted significant gaps in our knowledge, with relevance for our understanding of earthquake processes in general. **We are offering a fully-funded (at UK rate) DPhil project as part of a new collaborative Morocco-UK programme**, aimed at transforming our understanding of earthquake hazards across the region, by mapping the active fault sources, providing a new understanding of the rules they follow and hazards they pose, and building scientific outputs with a clear pathway to societal impact. The DPhil project will focus on the age and deformation of ancient shorelines along the Atlantic coast of Morocco, through the student will take an active role in field-based and remote sensing studies more widely across the country.

Marine terraces, representing coastal uplift in the late Quaternary, are present along large parts of the Atlantic coastline of Morocco. The Atlantic coast of Morocco offers a north-south transect through the east-west Atlas mountains as they intersect the coast, and the terraces, which are preserved right along this transect, offer means of examining rates and patterns of deformation. The uplift evidenced by the marine terraces occurs over a distance of several hundred kilometres, with sharp displacements and bending of terraces superimposed on a much broader swell. It is likely that the uplift of the terraces is driven by a combination of

deeper processes originating in the mantle (which form the broad domal uplift), and by active faulting, which causes the sharp displacements and bending.

A staircase of late Quaternary terraces at Cap Rhir, Morocco. Preliminary dating suggests these levels all date to within the last 120 ka. The ages will be confirmed and refined within this project.

The aim of this studentship is to quantify the Quaternary uplift of the Atlantic coast of Morocco through geological field mapping, satellite imagery, and quaternary dating. The student will then use their observations to examine the causes of uplift. They will dis-entangle the effects of past sea-level changes from tectonic motions, identify the presence of active faulting from sharp displacements and bending of the terrace levels, and determine rates and geometries of faulting from the ages of the terraces and from studies of the exposed geology in the coastal sections. The north-south coastal section through the Atlas mountains offers a rare opportunity to examine the distribution and relative importance of active faulting both at the margins and within the interior of a deforming mountain range.

There are important general aims, in terms of understanding the extent to which active faulting is distributed widely within zones of continental deformation, and to what extent vertical deformation within mountain ranges is driven by brittle faulting of the upper crust, and by deeper aseismic processes. There is also an important regional aim, in examining the context of the destructive 2023 Marrakech earthquake, whose epicentre was deep within the Atlas mountains. Through the project we will assess whether active fault structures exist at the surface within the interior parts of the mountains, or whether the 2023 earthquake fault instead is likely to link to faults that come to the surface at the margins of the range. The answer to that question has important implications for earthquake hazard in Morocco.

Methodology

The project would be ideally suited to a student interested in working at the boundaries of geology and geophysics on a topic that has implications for the vertical motions of the plates, sea-level changes, and tectonic hazards.

The project will involve a wide variety of field-based, analytical, and computational techniques. The extent and heights of marine terraces will be determined from the interpretation and analysis of high-resolution satellite imagery. Intensive fieldwork - required for the collection of samples to constrain the age of uplift - will provide training in the study of Quaternary coastal tectonics. The student will receive training in the preparation, and analysis, of samples for quaternary dating, remote-sensing, and the study of active faulting.

Timeline

Year 1: The first year will introduce the first stages of the project, and develop core skills and background knowledge of active tectonics in North Africa, of past changes in sea-level as recorded in the sedimentary record of ancient shorelines. A laboratory-based project will be selected to allow the student to learn the methods of satellite image analysis and digital topographic model (DEM) creation and analysis. We anticipate the first field work in the winder 2026-7 (~3 months into the project).

Years 2 and 3: Years two and three will consist of remote-sensing analysis, fieldwork, and the preparation and analysis of samples for Quaternary dating.

Year 4: Data integration, thesis completion, papers for international journals/conference presentation.

Training & Skills

The student will receive training in:

(a) Field methods relating to the project (i.e. coastal and tectonic geomorphology, sampling for a range of Quaternary dating techniques.

(b) Analysis of satellite imagery and digital topographic models to map and measure displacements and distortions of the earth's surface, as recorded by coastal terrace sequences. Construction of digital topographic datasets from stereo satellite imagery.

(d) The student would interact with the wider 'COMET' community of students and researchers, enabling wider training and sharing of knowledge

Further Information

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