Pre-Messinian connectivity of the Atlantic and Mediterranean (Ref IAP2-18-10)

University of Glasgow, Geographical and Earth Sciences

In partnership with Durham University

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Key Words

1. Sedimentology
2. Basin filling
3. Cosmogenic nuclides
4. Betic Orogen

Overview

The development of the Betic orogen reflects regional tectonics and the interplay between uplift, erosion and basin filling. In Spain, uplift of the Sierra Nevada and other blocks was accompanied by filling of intermontane basins which were periodically inter-linked to produce direct connections between the Atlantic and Mediterranean. Rapid basin fill is associated with high rates of denudation and source areas can be determined from distinctive changes in provenance of these fills. Although the timing of basin fill can be locally constrained through both thermochronological and biostratigraphic means, the sparse nature of such data mean that the timing of infill remains uncertain in many of the key locations. Hence, debates continue regarding the sequence of tectonic events and the timing of opening and closure of inter-oceanic corridors.

In this project you will use a novel suite of techniques and analyses to gain new insight into the sedimentary consequences of mountain building. This project aims to independently constrain the timing of closure of the Guadalhorce Corridor, which linked the two oceans. The project will develop new constraints on the timing of infill, and will provide new quantitative determination of the depositional environments. Taken together, these aims will enhance understanding of the evolution of the Betic orogen, and so contribute to a wider understanding of orogenesis.

Infill deposits can be found throughout the Betic orogen and surrounding basins. Particularly well-exposed deposits are found at el Chorro in the Guadalhorce Corridor. Here, van der Schee et al (2018) describe interbedded conglomerates and silts (80m), silts containing large cross-beds and rip-up clasts (190m), overlain by 120m of sands and conglomerates. Using a biostratigraphic marker, van der Schee et al conclude that this Corridor closed earlier than 7.51 Ma, in contrast to an estimate based on oxygen isotopes in foraminifera of 6.18Ma (Pérez-Asensio et al, 2012). The difference in these dates is extremely significant because of the role of closure of the links to the Atlantic in initiating the Messinian Salinity Crisis (5.97-5.33 Ma). As well as this difference in ages, different interpretations of the sedimentology of the sequence lead to debates about whether the connection had a two-way flow between the two oceans and hence about the potential for high-salinity
Mediterranean water to enter the North Atlantic, with implications for circulation and the climate of NW Europe.

The different dates for the el Chorro deposits that have been obtained are important, and this project seeks to provide independent dating of sedimentation. Cosmogenic burial dating (using 26Al and 10Be in quartz; Ciampalini et al 2015) will be used to determine the onset of major episodes of sedimentation. Samples will be collected from immediately above erosional surfaces towards the base of the sequence, towards the top, and from at least one location mid-sequence. Using two isotopes with differing half-lives, the onset of burial can be determined.

Field evidence for flow directions (uni- or bi-directional) at different elevations will inform interpretation of flow directions and the nature of the connection through time. Using established relationships between bedform geometry and flow properties (depth; velocity) the nature of the sedimentary environment will be quantified in greater detail than previously. Statistical modelling of palaeocurrent data will be used to infer potential sediment sources (Owen et al 2015).

Together with the burial dating, this sedimentological information will provide a new interpretation of the sequence, rate and type of infilling processes in the Guadalhorce Corridor. The project will include formal statistical comparison of dates obtained by different methods and at different locations in the sequence to test hypotheses regarding the timing of closure and the nature of the Corridor prior to its closure.

**Methodology**

Much of the infill at el Chorro is accessible on foot. The applied methods will include the following:

Fieldwork:
- (a) Sedimentary logging: grain-size; palaeocurrents;
- (b) Sampling for sediment analysis and micro-fossil biostratigraphy;
- (c) Drone flights to photograph the exposure, including inaccessible regions;
- (d) Sampling for cosmogenic dating.

Laboratory techniques:
- (e) SEM imaging and automated petrographic analysis (Durham);
- (f) Preparation of targets for cosmogenic nuclide analysis. Measurements will be made under the guidance of Dr Derek Fabel at SUERC (Scottish Universities Environmental Research Centre);

Data analysis:
- (g) Image processing and analysis (field images; SEM images);
- (h) Statistical analysis.

Because the exposure is so extensive in this area, field sampling will be planned following an initial reconnaissance visit during which an overview of the site will be obtained. Initial samples from key parts of the sequence will be used to inform detailed sampling in two subsequent extended periods of fieldwork.

**Timeline**

Year 1:
- Training in key field and laboratory skills
- Reconnaissance field visit and initial sampling (spring)
- Meta-analysis of published data
- Application to NERC Cosmogenic Isotope Analysis Facility (CIAF)

Year 2:
- Field work (2 x 4 week periods) – logging, drone photography, sampling
- Laboratory sample preparation and SEM analysis
- Conference attendance to present poster of initial data
- Cosmogenic measurement and analysis

Year 3:
- Cosmogenic measurement and analysis (Reserve date)
- Statistical analysis of all data
- International Conference to present main results
- Final analysis and write-up (extended to 3.5 years as required)

**Training & Skills**

Specific training depends on the prior skills and experience of the student, but will include several of:
- fieldwork safety and first aid
- field survey using drone and dGPS
- field sedimentology (logging; sampling)
- sample preparation for SEM and SEM operation and analysis
- mineral separation
- target preparation for cosmogenic nuclide dating
- principles of cosmogenic nuclide analysis, including error modelling
- advanced spatial statistics in R
- use of Matlab, Python and/or R for data analysis and presentation
References & Further Reading


Schoorl, JM and Veldkamp, A 2003 late Cenozoic landscape development and its tectonic implications for the Guadalhorce valley near Álora (Southern Spain) *Geomorphology* 50, 43-57


Further Information

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