SAGES PhD proposal: THEME 1

Title: Dating first order topography in Scotland: Constraining landscape in the Cairngorms using low temperature thermochronometry

Supervisors: Dr. C. Persano [BP-RSE post-doc and SAGES lecturer after that post-doc; email: Cristina.Persano@ges.gla.ac.uk] and Dr. K. Dobson [SAGES post-doc] (University of Glasgow); Dr. F. Stuart (SUERC); Prof. D. Macdonald (University of Aberdeen); Prof. D. Sugden (University of Edinburgh), in collaboration with BGS (Drs. Gillespie and Thomas).

The collaboration with BGS offers the possibility of further funds (consumables, field trips, conference attendance; up to £5,000) through the BUCS scheme.

The project background: The Cairngorms represent the largest portion of land above 900 m in the British Isles and are characterised by a landscape that is believed to be the result of surface processes that have been active since perhaps as much as 420 Ma (Macdonald et al. in press) (hereafter referred to as scenario 1) or of a “rejuvenation” event at ~60 Ma (e.g. Thomas, Gillespie et al. 2004) (hereafter referred to as scenario 2). This project will assess the antiquity of this classic Scottish landscape, providing the long-term landscape context and framework for shorter-term studies of Holocene and more recent landscape change and adjustment. This PhD project will test the two end-members scenarios, using a combination of low temperature thermochronometers and 3-D numerical modelling of landscape evolution over the long time scale (>10^6 years) (Figure 1).

Techniques and approaches and work: Autumn-spring 2008-2009: using the 3-D numerical model PECUBE (work station funded by a recent Royal Society grant), the student will determine the areas where the two scenarios can be most effectively tested. During this exercise s/he will also model and test the role of climate in enhancing erosion during the supposed 60 Ma denudation event.

Summer 2009 fieldwork is aimed at determining the role of geological structures (e.g. faults) on the landscape, focusing on key areas identified by Thomas et al. (2004). The field season will be preceded by the observation of landforms in aerial photographs, DEM (including LiDAR datasets) and satellite images.

Autumn 2009-summer 2010: the denudational history of the Cairngorms will be constrained using a combination of apatite fission track (AFT) and (U-Th)/He (AHe) thermochronometers along the profiles identified using PECUBE. About 20 samples will be analysed. Through a statistical approach the student will identify the scenario of landscape evolution that is most consistent with the thermochronometric data (summer 2010).

Training: The student will be trained in low-temperature thermochronometry, DEM image handling and 3-D numerical modelling of landscape evolution. S/he will also gain a thorough understanding of Scottish geology and glacial landscape evolution.

Figure 1: Time-temperature (T-t) thermal histories for scenario 1 (left: topography rejuvenation at ~60 Ma) and scenario 2 (right: no rejuvenation). The constraints included in the ovals are provided by the only AFT age from the Cairngorms (Hurford 1977) with its uncertainties. Using the software HeFTy, we have predicted the (U-Th)/He ages. Note that AHe ages are statistically different. The AFT data, although indistinguishable in the two scenarios, are indispensable to constrain the T-t paths used to predict the AHe age.
The project depends on facilities that are already in place (apatite fission track laboratory and computer workstation for the numerical modelling at Glasgow, apatite (U-Th)/He laboratory at SUERC) or will be in place before October 2007. Further funding for consumables, field-trips and conference attendances will be sought through the collaboration with BGS.

Summary: This project aims at assessing the antiquity of the landscape in the Cairngorms, the largest portion of land above 900 m in the British Isles, using a combination of low temperature thermochronometers and 3-D numerical modelling of landscape evolution.

The project and SAGES Theme 1: The principal aim of SAGES Theme 1 is to constrain and understand how the landscape evolves through time. The constraints on the rate at which surface processes shape the landscape will be used to better calibrate and validate numerical models of landscape evolution that can be in turn used for meaningful prediction about the future evolution of the landscape, following a tectonic and/or climate change. The notion that the landscape response to a perturbation is effective on a time scale that may vary from seconds to million of years leads to the necessity of constraining landscape evolution at a range of time scales. This project aims at constraining the evolution of the first order topography in the Cairngorms as one of the most striking area of the British Isles. The modus operandi chosen for this project perfectly matches that of SAGES Theme 1, as the project objectives are: 1) to predict and study possible scenarios of landscape evolution using 3-D numerical modelling; 2) to measure rates of surface processes and their spatial and temporal variation; and 3) to use the empirical constraints to validate the scenarios derived from the 3-D numerical model. These rates of surface processes, averaged over the long-time period, will determine the age of the first order topography in the Cairngorms, providing the context within which to assess the role of Cenozoic and in particular Quaternary tectonic and climatic changes. All the supervisors have been interested in understanding and constraining the evolution of the Scottish landscape for many years. The novelty of this project is represented by its genuinely inter-disciplinary and multi-disciplinary nature whereby expertise in thermochronology (Drs. Persano, Dobson and Stuart), numerical modelling (Dr. Persano), Scottish geology (Prof. Macdonald, BGS) and glacial landscape evolution (Prof. Sugden) are combined to provide the first robust framework for understanding landscape changes and adjustments. The project therefore represents an invaluable opportunity for researchers from several Universities (and BGS) within SAGES Theme 1 to act as a team, and explore new ideas of collaboration.

The project will use the unique facilities available in the Department of Geographical & Earth Sciences at the University of Glasgow (fission track laboratory and numerical modelling) and at SUERC ((U-Th)/He laboratory) and it will be an important contribution for keeping SAGES at the forefront of international research.

References:

