Controls on valley-floor width and lateral erosion rates in confined mountain valleys
2-year post-doctoral fellow or 3-year PhD student

Context

Mountain floodplains are important components of fluvial systems: as they are the flattest and most fertile regions in mountain environments, they tend to be where settlements, vegetation, and farming are concentrated. Wide, flat valley floors also act as transient sinks for sediment generated at high elevations on its downstream journey to ocean basins. This floodplain sediment is an important control on flood hazard: sediment deposition can reduce channel conveyance capacity, therefore increasing flood risk (Slater et al., 2015). As floods travel downstream, they can also entrain sediment stored within the valley floor. This causes sediment-rich flows, which travel vast distances compared to clearwater flows, causing loss of life and damage to infrastructure (Westoby et al., 2014). Sediment stored within mountain valleys therefore acts as an important linking node between upstream hazards such as earthquakes, landsliding, and debris flows; and downstream hazards such as floods.

We currently lack understanding of how rivers erode laterally into their valley walls and what controls the resulting floodplain shape. Gilbert (1877) suggested that lateral erosion occurs when channel beds become alluviated, causing deflection of particles to the channel banks and enhanced lateral erosion (e.g. Fuller et al., 2016). This hypothesis suggests that lateral erosion is likely to outpace vertical incision when sediment supply is greater than channel transport capacity, although lateral erosion has also been suggested to occur during extreme discharge (Cook et al., 2014) or through meander migration (e.g. Finnegan and Dietrich, 2011). However, there exist few direct measurements of bedrock lateral erosion to test these models. Valley widening should occur by lateral bank erosion at times when the channel migrates laterally over the floodplain and impinges upon the valley sidewalls (e.g. Hancock and Anderson, 2002; Turowski et al., 2023). Therefore, valley-floor width could serve as a useful proxy for lateral channel erosion over valley-forming timescales. Empirical studies have found that valley-floor width is correlated with catchment discharge or drainage area (e.g. Tomkin et al., 2003; Brocard and van der Beek, 2006; May et al., 2013,), erodibility of the valley walls (e.g. Langston and Temme, 2019), valley wall height (e.g. Tofelde et al., 2022), upstream and lateral sediment supply, and tectonic uplift (e.g. Clubb et al., 2023), yet we are lacking a robust theoretical understanding of the importance of each of these parameters on setting valley-floor width.

Project aims

Recent work has led to the development of new tools to quantify valley-floor morphology at the mountain belt scale (Clubb et al., 2022, 2023), providing datasets which can be used to test emerging models of valley-floor shape. In concert, advances in landscape evolution modelling have led to the development of new hydrodynamic models which simulate lateral channel mobility and allow prediction of active channel widths and flow depths (Davy et al. 2017). The project scope is flexible depending on the skills, experience, and interest of the candidate, but will combine new datasets of valley-floor width from high-resolution topographic data with landscape evolution modelling to investigate which factors controls valley shape and lateral erosion rates in mountain regions. It will focus on actively uplifting mountain ranges such as the Himalaya, New Zealand, and Taiwan. It will address the following key questions:

1) *How do tectonic uplift, water discharge, sediment supply, and bedrock erodibility influence valley-floor widths in confined mountain valleys?*
2) *How do valley-floor widths and rates of lateral erosion evolve with varying scenarios of water discharge, sediment supply, and tectonic uplift?*
3) *How does the episodic lateral input of sediment from surrounding hillslopes influence valley geometry?*
4) *What are the controls on channel mobility within confined fluvial valleys?*

5) *What is the role of extreme floods in shaping fluvial valleys?*

Supervision

Philippe Steer (Univ Rennes), Fiona Clubb (Univ Durham), Boris Gailleton (Univ Rennes), Philippe Davy (Univ Rennes). Collaborations with Dimitri Lague (Univ Rennes) and Sébastien Carretier (Univ Toulouse)

Person specification notes

We would like a 2-year post-doctoral fellow or 3-year PhD student with interest and experience in quantitative geomorphology, topographic analysis, and ideally with a background in numerical modelling.

Essential criteria (post-doc level):

- Completed, or nearly completed, a PhD in geomorphology or a closely related discipline.
- Established expertise and relevant research experience in geomorphology, ideally with a focus on fluvial geomorphology, topographic analysis, or numerical modelling.
- Ability to write scientific papers, to communicate in a scientific environment and to collaborate with a multi-cultural team.

Desirable criteria (post-doc level):

- Experience working with and manipulating digital topographic data.
- Experience with numerical models of landscape evolution or hydrology.
- Experience working with quantitative geoscientific data.
- Experience with one or more programming languages e.g. Python, Matlab, R, C++.

Location

The hired person will be located in Rennes (France), but will regularly visit Durham (UK). Rennes, the capital of Brittany, is a very lively human-scale city and is located just 1,5 hour away from Paris and less than 1 hour from sunny beaches. University of Rennes is amongst the ten main universities in France. It is a multidisciplinary university, famous for its excellence and dynamic research. The Geosciences department is a large and multidisciplinary research centre which is internationally recognized for its quality in environmental research, in particular in hydro(geo)logy, geomorphology and numerical modelling.

Salary

The salary will depend on experience and qualification of the candidate.