

## Summary of the project:

Rivers transport water and sediment from upland areas to the coast. Rivers normally have a sediment bed (called alluvial channels), but in some areas the underlying bedrock is exposed in the channel (producing bedrock river sections). In comparison to several decades of research on alluvial channels, far fewer studies have focused on bedrock rivers (Whipple, 2004). This lack of knowledge is problematic because sections of river with exposed bedrock are very common in upland parts of river systems, and existing research (Hodge, 2011; Ferguson, 2017; Whitbread, 2015; Wohl, 2008; Sklar, 2004; Turowski, 2008) shows that the presence of exposed bedrock can significantly alter water and sediment transport processes, which in turn affects the range of biological habitats in the channel. However, we do not know what controls the spatial occurrence of bedrock river sections. This is problematic because:

1. Anthropogenic changes to rivers such as dams, hydro-power schemes and management have the potential to change the exposure of bedrock in the channel, The bedrock beds are often smoother than sediment beds, making it easier to transport sediment and water over them. Over long time periods, the erosion of the exposed bedrock will lower the elevation of the river which is one of the main ways in which landscapes respond to changes in tectonics and climate. but without better understanding this change we cannot predict where and whether this will occur.
2. Downward erosion of bedrock rivers is a key process in landscape evolution (changing topography over time), but sediment cover inhibits this process and so we need to understand where bedrock will be exposed in order to predict landscape evolution.
3. Bedrock river sections interrupt the normal pattern of downstream changes in grain size, making it harder to predict river channel properties at a network scale.

The amount of bedrock that is exposed in river beds is thought to depend on the amount of sediment that is supplied to the river, and the ability of the river flow to move the sediment (Whipple, 2004). Bedrock exposure is expected to occur when sediment supply is low, and/or the transport capacity is high (Sklar, 2004). Changes in bedrock exposure could occur when sediment is supplied or transported sporadically in large amounts such as during floods or landslides, which would lead to very sudden changes in topography and bed morphology (the shape of the river bed).

The amount of sediment supplied will depend on the erosion rate of the river catchment, whereas the transport capacity depends on the channel steepness and the water depth or discharge (Turowski, 2008)

The aim of this project is to evaluate the controls on bedrock exposure in river channels in the USA. This will be the first attempt to identify controls on bedrock exposure in rivers over this spatial scale.

The project will use a large dataset to identify any correlations between bedrock exposure, channel characteristics (e.g. channel form, sediment grain size distribution, channel size and gradient, bankfull and flood discharges), and catchment characteristics (e.g. catchment size, elevation, geology, climate). Some of the data have already been compiled, whereas others will be extracted using analysis of digital elevation models of the river catchments and analysis of river depth data from gauging stations. There is also potential to include analysis of erosion rate data collected using analysis of cosmogenic isotopes (e.g. <https://www.earth-syst-sci-data.net/10/2123/2018/> and <https://earth.uow.edu.au/>). Although bedrock exposure can vary through time at any one location, by using a large dataset we still expect to be able to identify overall trends. This project draws on analytical methods used by Pfeiffer et al to understand controls on alluvial channel properties, but is the first time that this approach has been used on bedrock channels (Pfeiffer, 2017).

#### Objectives:

1. To identify suitable catchments from the channel property dataset, and to compile relevant data for these channels (e.g. channel width and depth, sediment grain size, bedrock exposure).
2. To analyse USGS flow records from the identified catchments in order to identify average and extreme flow conditions.
3. To analyse DEM and geological data from the catchments, in order to calculate catchment properties (e.g. area, slope, length, elevation, lithology).
4. To analyse cosmogenic erosion datasets to see whether these data can be used to estimate erosion rates in these catchments.
5. To analyse the datasets from the previous objectives to identify whether there are any relationships between these factors and bedrock exposure.

Ferguson, R.I., Sharma, B.P., Hodge, R.A., Hardy, R.J. and Warburton, J., 2017. Bed load tracer mobility in a mixed bedrock/alluvial channel. *Journal of Geophysical Research: Earth Surface*, 122(4), pp.807-822.

Hodge, R.A., Hoey, T.B. and Sklar, L.S., 2011. Bed load transport in bedrock rivers: The role of sediment cover in grain entrainment, translation, and deposition. *Journal of Geophysical Research: Earth Surface*, 116(F4).

Pfeiffer, A.M., Finnegan, N.J., Willenbring, J.K., 2017. Sediment supply controls equilibrium channel geometry in gravel rivers. PNAS 201612907. <https://doi.org/10.1073/pnas.1612907114>

Sklar, L.S. and Dietrich, W.E., 2004. A mechanistic model for river incision into bedrock by saltating bed load. *Water Resources Research*, 40(6).

Turowski, J.M., Hovius, N., Wilson, A. and Horng, M.J., 2008. Hydraulic geometry, river sediment and the definition of bedrock channels. *Geomorphology*, 99(1-4), pp.26-38.

Whipple, K.X., 2004. Bedrock rivers and the geomorphology of active orogens. *Annu. Rev. Earth Planet. Sci.*, 32, pp.151-185.

Whitbread, K., Jansen, J., Bishop, P. and Attal, M., 2015. Substrate, sediment, and slope controls on bedrock channel geometry in postglacial streams. *Journal of Geophysical Research: Earth Surface*, 120(5), pp.779-798.

Wohl, E. and David, G.C., 2008. Consistency of scaling relations among bedrock and alluvial channels. *Journal of Geophysical Research: Earth Surface*, 113(F4).