Research Experience Placement (REP) Scheme 2023

Supervisor Project Proforma

Project title:	Investigating the signature of chemical erosion at Moor House, North Pennines
Host Institution:	Loughborough University
Project supervisor (name, department):	Dr Edwin Baynes, Geography and Environment
Project enquiries (supervisor email):	e.baynes@lboro.ac.uk
Co-Supervisor, if any (name, department):	
Proposed start date:	3rd July 2023

Project description (max 700 words, 1-2 figures may be included):

Proposed projects must:

- have a clearly defined objective.
- be within the science remit of NERC.
- be feasible for a student to complete within the timescale of the award.
- include more than purely a computer/modelling component i.e., some element of fieldwork, data collection, activity to give an understanding of the wider context etc.*
- give scope for thought and initiative on the part of the student and should not use the student as a general assistant.
- be based at an eligible UK research organisation (remote placements are also an option for enabling inclusivity).

Bedrock reaches are commonplace in UK upland environments, and their erosional processes are set primarily by climatic and lithological controls, including flood frequency, flood magnitude, and bedrock characteristics. The balance of these controls sets the relative rates of chemical denudation (e.g., dissolution by water flow) and physical denudation (e.g. abrasion/plucking during floods) for the long-term evolution and morphology of bedrock rivers. At present, we lack a quantitative understanding of the balance between in situ chemical and physical erosion due to extremely limited high quality field data (Covington et al. 2015).

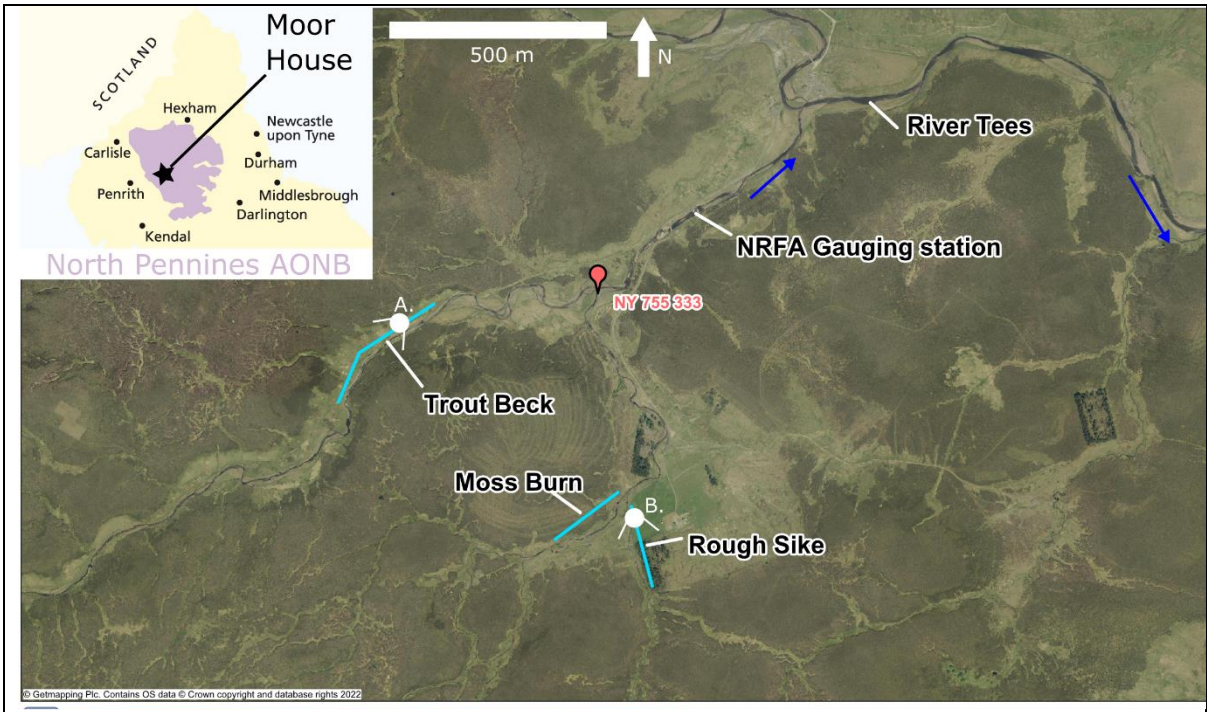
Extreme rainfall events will become more frequent in the future, potentially shifting the rates of, and relative importance of, chemical and physical erosional processes. More frequent active sediment transport conditions during floods may increase both the physical denudation rates and the coupled chemical rates through increased exposure of fresh surfaces following sediment impacts. Therefore, climatic changes may lead to non-linear increased erosion rates in UK uplands and alterations in river morphology and behaviour. However, without a detailed understanding of the existing signature of chemical erosion in upland rivers, it is difficult to characterise representative erosion rates and predict future climate-induced changes in specific processes (Covington et al. 2015).

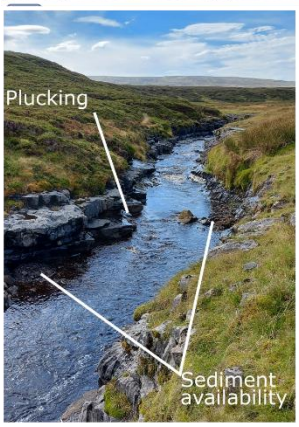
This will undertake fieldwork to examine the characteristics of chemical erosion features (e.g., micro- and macro-karren) in two rivers at Moor House, North Pennines (Figure 1), that partly form the headwaters of the Tees and are characterised by a flashy hydrological regime. Trout Beck (drainage area 8 km^2) and Rough Sike (1 km^2) are distinct geomorphologically (e.g. sediment availability from upstream: transport-limited in Trout Beck, supply-limited in Rough Sike), and both chemical and physical erosion processes are active to varying extents due to the

Carboniferous limestone bedrock. It is hypothesised that chemical erosion dominates in Rough Sike, whereas erosion in Trout Beck is a combination of chemical and sediment transport-driven physical erosion. The understanding of impact of the different erosion regimes in the two rivers, while all other factors (geology, climate) are held constant, on the morphology of the channels is currently limited to a small pilot study conducted in 2022, suggesting that karren features are more visible in Rough Sike and Trout Beck has a systematically higher width-depth ratio.

This REP project will use a Schmidt Hammer to measure rock rebound values (a proxy for rock strength; see Larimer et al. 2022) of the bedrock exposed within both rivers, with lower strength expected for rocks where prolonged exposure to chemical weathering leads to a weaker rock surface (expected in Rough Sike) and higher rock strength in locations where physical erosion maintains 'fresh' rock at the surface (expected in Trout Beck). After the fieldwork, the student will undertake statistical analysis of the Schmidt Hammer values, and topographic surveys of the channel morphology to identify any significant differences between the two channels that can be interpreted as the result of the balance of chemical and physical erosion.

These Schmidt hammer measurements will be taken on an along-stream transect in both channels, as well as cross-sectional profiles to explore differences with height above the active channel. Additional precise sampling locations can be determined by the student according to their interests; with possibilities including micro-scale variability in rock hardness within and between small-scale karren features. The student will be given flexibility to explore research questions within the unique bedrock river observatory setting of Moor House.





A. Trout Beck

B. Rough Sike

C. Chemical dissolution

Figure caption: Map and aerial image Moor House, located within the North Pennines Area of Outstanding Natural Beauty in Northern England. The bedrock reaches targeted for long-term geomorphological monitoring (highlighted on the aerial image in light blue). Trout Beck (A) is the largest system with sediment available for transport from upstream while Rough Sike (B) is smaller with limited sediment available for transport. Evidence for physical denudation (e.g., plucking of blocks from the banks) and dissolution features on the bed are present in all three bedrock reaches. Historic sediment tracers from Trout Beck (C) show evidence of erosion by dissolution, with areas covered by paint (the number '163') protected from erosion and forming relief on the pebble surface. Dark blue arrows show direction of river flow. Sources: Aerial image: EDINA Digimap (Ordnance Survey), Inset map: North Pennines AONB, Field photos (A&B): E. Baynes, Pebble photo (C): J. Warburton.

Project timeline:

Week 1: Fieldwork planning, including site selection for targeted Schmidt Hammer measurements. Student to determine precise research questions (e.g., exploring smallscale karren feature strength differences, or exploring larger scale variations with location in channel cross-section)

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Week 2: Field data collection at Moor House Week 3-5: Statistical analysis of field data, with reference to existing smallscale pilot dataset. Week 6: Consideration of publication strategies for complete dataset, in collaboration with supervisor.
Candidate requirements:
- Understanding of fluvial geomorphology, including interest in bedrock rivers and erosion processes. Knowledge of/interest in chemical erosion processes would be advantageous. - Quantitative analysis skills
Background reading and references:
Covington, M. D., Gulley, J. D., and Gabrovšek, F. (2015) Natural variations in calcite dissolution rates in streams: Controls, implications, and open questions. Geophysical Research Letters 42(8): 2836–2843. Larimer, J. E., Yanites, B. J., and Jung, S. J. (2022) A Field Study on the Lithological Influence on the Interaction Between Weathering and Abrasion Processes in Bedrock Rivers. Journal of Geophysical Research: Earth Surface 127(4): e2021JF006418. Sklar, L. S., and Dietrich, W. E. (2001) Sediment and rock strength controls on river incision into bedrock. Geology 29(12): 1087–1090.

To be completed by institutional CENTA PoC

I confirm that:

- Appropriate supervisory arrangements are in place
- Any necessary ethical committee approvals, animal licences & requirements of regulatory authorities will be in place before the work begins and will be maintained for the duration of the project
- We will take responsibility for identification, protection & exploitation of any intellectual property rights arising from the project
- All facilities, agreements regarding access and collaborations necessary for the work will be obtained before the work commences and can be ensured for the duration of the project
- All costs awarded by NERC for the REP will be used and accounted for appropriately
- A report of the project by the student will be submitted no later than one week after the end date of the placement or 15th September 2023, whichever falls first.

Signed: 

Date: May 3rd 2023

Position: Professor of Environmental Change; Centa Point of Contact for Loughborough University