

Constraining the discharge regimes of rivers in deep time

Project Supervisors

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Summary:

Ancient river deposits provide a crucial archive of landscape response to environmental and tectonic forcing. New methods for quantifying the palaeohydrology and intermittency of rivers now mean that we can draw sophisticated insights into the dynamics and sensitivity of river systems in the past. This is important because constraining how ancient fluvial systems responded to environmental change in the geologic record provides valuable information on the impact of future climate change on modern rivers in a warming world. This project will constrain spatial variations in discharge regimes for two ancient river systems in the UK that differed in scale and size, represented by the Triassic Sherwood Sandstone and early Cretaceous Tunbridge Wells Sands. The research will exploit outcrop data and palaeo-digital elevation models (pDEMs) to place these results in the context of global constraints on modern and ancient river systems as a function of climate for the first time.

Research Context and Work Packages (WPs).

The Sherwood Sandstone Group (SSG) of the British Isles is a large, regionally significant unit of Triassic fluvial and aeolian sandstones, deposited at low latitudes in central Pangea c. 250 to 240 Ma, with exposures onshore stretching across large parts of England. It records dryland sedimentation under very warm conditions during the climatic recovery period following the Permo-Triassic Mass Extinction. The unit is also significant for the geological storage of carbon dioxide and groundwater resources in the UK. Recent work from Imperial presents a new appraisal of source to sink sediment routing in the SSG¹, refining timelines and sediment volumetrics for this system, enabling a source to sink palaeohydrological appraisal to be possible for the first time. Work from the same team including the project supervisors has provided estimates of channel dimensions and discharges for part of the system that outcrops in Devon, south-west England illustrating that this approach can be applied successfully to fluvial rocks. In contrast, the early Cretaceous Tunbridge Wells sands broadly represent a non-marine interval in the Wealden of south-east England, with fluvial and deltaic sediments apparently derived from the London massif to the north and from the Armorican massif to the south, around 135 million years ago. This period was a time of short-lived cooling within the Cretaceous greenhouse, which has been interpreted by some authors to feature highly seasonal conditions between wet cool winters and warm summers. Little modern work has been carried out on this system, and quantitative palaeohydrological reconstructions have never before been attempted.

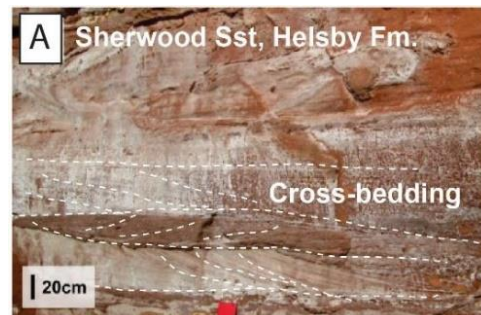


Fig. 1 – (A) Cross bedding in the SSG; (B) Example of fluvial sandstones in the Tunbridge Wells Sands; (C) Potential modern equivalent – a dryland sandbed river

IMPERIAL

WP1: Palaeohydrology of two ancient rivers: The student will make primary observations of the sedimentary characteristics the two systems, using primary field data and 3D outcrop scanning. In the field channel architectures will be documented and 3D LIDAR and drone outcrop scans created to provide a template on to which field measurements can be spatially located. Bedform data, sediment grain size, observations of bar preservation and height will be used to develop constraints on paleoflow depth at each locality. Barform lengths and preserved channel body widths will provide constraints on plausible channel widths. Additional scaled measurements and constraints on channel architecture will be recovered from the digital outcrop models, where accessibility constraints prevent in-situ measurement. These measurements will be systematically integrated with qualitative sedimentary facies evidence (e.g., transitional or supercritical bedforms, log-jam deposits, crevasse splays, floodplain palaeosols & slack-water deposits) providing direct evidence of flood and low-flow conditions.

WP2: Palaeohydrological Reconstruction. The field data will be processed through a quantitative palaeohydrology workflow developed at Imperial². This will produce estimates of channel depth, H , derived from bedform and barform measurements, and palaeoslope, S , based on depth, grain size measurements and width. Bankfull water fluxes will be estimated using flow velocity and channel geometry reconstructions, and sediment transport capacity will be calculated using a grain size appropriate formulation. Where possible, these data will be presented as a function of down-system distance, informed by regional geology and palaeocurrent measurements. Quantitative hydrological data will be systematically compared with facies-based reconstructions of depositional style, and river planform (e.g. single threaded, meandering, braided).

WP3 Climate and sediment water budgets The student will constrain time-averaged sediment and water fluxes for the two river systems from geologically mapped volumes integrated across depocentres. Plausible source catchment sizes and palaeo-sediment routing system constraints will be reconstructed using available palaeo-geographies and pDEMs for the time intervals under consideration. Climate, water and sediment budgets will be estimated from the same derived catchment areas and precipitation constraints from palaeoclimate models and geochemistry studies.

WP4 Intermittency and comparison with data. The student will estimate the intermittency of sediment and water fluxes by considering the ratio of longer-term water and sediment budgets from WP3 compared with the bankful budgets estimated by paleohydrological approaches in WP2. These data will be compared statistically with modern rivers, and their sensitivity to current climate regimes.

Who are we looking for?

We are looking for a motivated geoscientist who is excited to work on an inter-disciplinary project involving field geology, sedimentology, photogrammetry and DEM analyses. The project is ideally suited to students who have interests in the fields of sedimentology, river dynamics and landscape sensitivity to climate. Previous experience of research, for instance at MSci or MSc level is desirable but not essential. The student will get training in the interpretation of fluvial stratigraphy, palaeohydrology, well data and DEM methods. The student will join a large, active research group (the Landscapes and Basins Research Group) with interests in surface processes, sedimentology, structural geology and basin analysis, and a strong track record in the integrated application of these disciplines.

Further reading

¹Yan, X., Hampson, G., Whittaker, A.C., 2026, A new source-to-sink synthesis of the Middle Triassic Helsby Sandstone Formation (Sherwood Sandstone Group) river system in the British Isles, *Journal of the Geological Society*, 183 (4): jgs2025-214, <https://doi.org/10.1144/jgs2025-214>

²Lyster, S., Whittaker, A.C, Hampson, G., Hajek, E., Allison, P. Lathrop, B., 2021, Reconstructing the morphologies and hydrodynamics of ancient rivers from source to sink: Cretaceous Western Interior Basin, Utah, USA, *Sedimentology*, 68, 2854-2886.