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A geomorphic-geochemical framework for quantifying the cycling of sediment-associated contaminants in fluvial systems

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Recent high-profile contamination events linked to extreme floods have underlined the persistent environmental risk posed by legacy metals stored in fluvial systems worldwide. While we understand that the fate of sediment-associated metals is largely determined by the dynamics of the fluvial transport system, we still lack a process-based understanding of the spatial and temporal mechanisms that affect the physical and geochemical transfer of metals through catchments. This interdisciplinary project will exploit advances in geomorphic and geochemical analyses to develop a methodological approach and conceptual framework to answer key questions related to the dynamics and timescales of metal cycling in fluvial systems. The approach will be tested in two reaches of the mining-impacted Afon Twymyn, Wales. The main objectives are: (i) quantify the physical transport of sediment and metals over a range of river flows and model sediment pathways; (ii) establish the geochemical mobility and speciation of sediment-associated metals and how this is modified through the sediment pathways. To achieve these objectives a geomorphic-geochemical combined methodology will be applied. It includes: (i) Aerial imagery that will be acquired from UAV surveys pre- and post-high flows and transformed into high-resolution DEMs using Structure-from-Motion; (ii) suspended sediment flux will be estimated indirectly by field calibration with a logging turbidimeter; (iii) 2D hydraulic and sediment transport model (Delft3D) will be used to quantify the transport of sediment and associated metals and to map the source, pathway and sink of contaminated sediment; (iv) soil and sediment samples (including suspended sediment) will be collected pre- and post-high flows for geochemical (concentration, speciation) and mineralogical (XRD, SEM) analyses; (v) finally, a geochemical model (Geochemists Workbench) will be developed to generate hypotheses that explain observed geochemical change as a function of sediment pathways.