Geophysical Research Abstracts
Vol. 15, EGU2013-471, 2013
EGU General Assembly 2013

A multi-proxy lake sediment record of recent anthropogenic influence on catchment processes from Brotherswater, northwest England

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As geomorphologists engage with the Anthropocene debate, it is increasingly recognised that new data sources are integral to disentangling human-induced landscape evolution from other drivers. Upland lake basins record the geomorphic effects of catchment processes due to their efficient trapping of catchment-derived sediment flux, rendering lake sediment sequences a valuable but underutilized resource.

High-resolution (0.5 cm) particle size, geochemical and thermogravimetric data for a series of abyssal lake sediment cores (short gravity cores collecting the water-mud interface and 3 – 5 m long cores) from Brotherswater, a small upland waterbody in the English Lake District, exhibit concurrent shifts between a number of sedimentological proxies and the expansion of human activity within the catchment over recent centuries. Well-constrained chronologies are derived for the cores using radionuclide (210Pb, 137Cs, 214Am, 14C) dating and elemental signatures which reflect distinct phases of the local mining history (e.g., Pb, Zn, Ba). Precise core correlation using geochemical and magnetic profiles has facilitated the transfer of age-depth models between cores and the identification of the spatial patterning of sediment flux diffusion across the lake.

Increased concentrations of terrigenous geochemical tracers (e.g., Zr, Ti, K) and greater soil carbon flux appear to coincide with the onset of 19th century intensive mining. End-member modelling of particle size distributions highlights a contemporaneous coarsening in the calibre of deposited sediment, indicating a substantial shift in the nature of sediment supply. Post-mining hillslope stabilisation and an ensuing adjustment of the catchment to a permanently altered background state are also recognised in the geochemical records, particularly the Pb profile. Numerous coarse-grained laminations within the sediment sequence are interpreted to represent discrete extreme floods, reflecting the hydrodynamic relationship between river discharge and particle size delivery. These coarse-grained facies correlate well to the historical flood record for the Eden catchment spanning the last 300 years, offering insight into how the frequency and magnitude of extreme events have responded to phases of human activity.

We provide a successful demonstration that applying multiple proxy techniques to lake sediment archives enables signals of local anthropogenic influence to be extracted and the resultant influence on catchment sediment regimes and extreme hydrological events to be reconstructed.