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Lakes as recorders of extreme flows: utilising particle size analysis to generate a millennial-scale palaeoflood record from the English Lake District

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Developing new quantitative measures of catchment processes, such as flood events, is a key goal of geomorphologists. The geomorphic effects of extreme hydrological events are effectively recorded in upland lake basins as efficient sediment trapping renders flow-related proxy indicators (e.g., particle size) reflective of changes in river discharge. We demonstrate that integrating particle size analysis of lake sediment cores with data from an on-going sediment trapping protocol within the lake can provide a valuable natural archive for investigating hydrogeomorphic extremes over extended time periods.

A series of sediment cores (3 – 5 m length) extracted from Brotherswater, English Lake District, contain numerous coarse-grained laminations, discerned by applying high-resolution (0.5 cm) laser granulometry and interpreted to reflect a palaeoflood record extending to ∼2000 yr BP. Well-constrained core chronologies are derived through integrating radionuclide (210Pb, 137Cs, 241Am, 14C) dating with geochemical markers which reflect phases of local lead (Pb) mining. Geochemical and magnetic profiles have facilitated precise core correlation and the repeatability of the distinctive coarse facies to be verified. That these laminae exhibit inverse grading underlying normal grading, most likely reflecting the waxing and waning of flood-induced hyperpycnal flows, supports our palaeoflood interpretation.

Application of a recently-published end-member model for unmixing particle size distributions (Deitze et al., 2012) demonstrates a prominent coarse end-member (medium sand) which we attribute to fluvial transport of coarse grains during high-magnitude flows. Two end members feature in the silt-size fraction, most likely reflecting the sedimentary component delivered under normal flow conditions. The relative importance of these two modes appears to respond to catchment conditioning due to land-use change, which has important implications for how flood events may be recorded in the sedimentary archive through time.

First data from the sediment traps installed at three depths at two locations in Brotherswater (sampled monthly) display similar particle size distributions, providing good verification of the process-response inferred from the lake sediment record. Vertical grain size variability within the sediment traps also provides useful insight into the possible role of hyperpycnal flows at Brotherswater. These data are a particularly valuable contribution to the expanding literature investigating the potential for lake sediment sequences to record signatures of historical high-magnitude flood events.

Deitze, E. et al. (2012) An end-member algorithm for deciphering modern detrital processes from lake sediments at Lake Donggi Cona, NE Tibetan Plateau, China. Sedimentary Geology 243-244, 169-180.