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Brotherswater, English Lake District: a record of organic and inorganic sediment flux over the past two millenia

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Lake sediments have long been recognised as efficient recorders of geomorphic change through time and they also function as a proportionally large carbon sink within the global C cycle. However, calculating carbon budgets for lake basins can prove challenging due to the spatially variable pattern of sediment accumulation within the basin and the heterogeneous nature of the organic matter accumulating on the lake floor, which can comprise autogenic organic material, eroded soil organic floccules and plant biomass from the catchments.

High-resolution (0.5 cm) particle size, geochemical and thermogravimetric data for a series of abyssal lake sediment cores (3 – 5 m length) are used to examine the relationship between hydrological conditioning, sediment dynamics and particulate carbon flux over the past 2000 years for a small upland catchment in the English Lake District (Brotherswater). Core correlation using geochemical and mineral magnetic profiles has facilitated the identification of the spatial pattern of inorganic and organic sediment accumulation within the lake. A well-constrained chronology has been developed, incorporating radionuclide (210Pb, 137Cs and 14C) dating and elemental signatures which reflect the mining history of the catchment (e.g., Pb, Ba and Zn).

The role of climatic fluctuations and human activity (e.g., the Little Ice Age, agricultural intensification during Roman and Viking periods) in controlling catchment-to-lake sediment flux is well studied in northwest England, and these phases are reflected in inorganic geochemical markers (e.g., Sr, Zr, K) in the lake sediment cores. Recently accumulated sediments yield geochemical signatures of substantial heavy metal flux (lead, zinc and barium) associated with intensive mining in the catchment, while numerous coarse-grained facies are visible within the silt-dominated lake sediment matrix, which are interpreted as reflecting late-Holocene high-magnitude flood events.

Using thermogravimetric (TGA) profiles for the sediment cores, measured using an increasing burn rate from 25°C to 950°C under nitrogen, we have calculated carbon budgets at sub-decadal to centennial timescales for the past two millennia. These data also reveal, to some extent, the nature of accumulating organic matter through the thermal transformation signatures. The temporal pattern of carbon accumulation within the lake is contrasted with records of inorganic sediment flux (phases of hillslope erosion and heavy metal deposition) and the sedimentological palaeoflood stratigraphy to assess external conditioning of the lake carbon budget.