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Sedimentary processes in High Arctic lakes (Cape Bounty, Melville Island, Canada): What do sediments really record?

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Lacustrine sedimentary sequences can hold a substantial amount of information regarding paleoenvironments, hydroclimate variability and extreme events, providing critical insights into past climate change. The study of lacustrine sediments is often limited to the analysis of sediment cores from which past changes are inferred. However, studies have provided evidence that the accumulation of sediments in lacustrine basins and their distribution can be affected by a wide range of internal and external forcing mechanisms. It is therefore crucial to have a good knowledge of the factors controlling the transport and distribution of sediments in lakes prior to investigating paleoenvironmental archives. To address this knowledge gap, the Cape Bounty Arctic Watershed Observatory (CBAWO), located on southern Melville Island in the Canadian High Arctic, was initiated in 2003 as a long term monitoring site with the aim of understanding the controls over sediment transport within similar paired watersheds and lakes.

The East and West lakes have been monitored each year since 2003 to document the role of hydro-climate variability on water column processes and sediment deposition. Moorings recording water electrical conductivity, temperature, density, dissolved oxygen and turbidity, as well as sediment traps were deployed during the active hydrological period (generally May-July). These data were analyzed in combination with hydrological and climatic data from the watersheds. Additionally, a high-resolution bathymetric and sub-bottom survey was completed in 2015 and allowed imaging the lake floor and sub-surface in great detail. This combination of process and lake morphological data are unique in the Arctic.

The morphostratigraphic analysis reveals two highly disturbed lake floors, being widely affected by sub-aqueous mass movements that were triggered during the last 2000 years. Backscatter intensity maps and the presence of bedforms on each delta foresets indicate that underflows (turbidity currents) generated at the river mouths are frequent and deliver coarse-grained sediments to the deeper waters. According to the 2003-2014 mooring data, no single hydroclimatic process can explain this underflow activity. Spring snowmelt is often responsible for delivering a substantial amount of sediment to the lakes in the form of underflows, while the contribution of summer rainfalls has also been important in some years. However, one of the largest rainfall recorded (100 mm over four days in August 2013) did not trigger a corresponding underflow event in West Lake, confirming that antecedent soil conditions can significantly reduce runoff and suspended sediment concentrations in the rivers. Moreover, high peaks of turbidity were recorded below ice cover, during the winter, a season thought to be inactive in terms of sedimentary processes. Hence, reconciling the range of processes responsible for sediment deposition and that generate both bedforms and subaqueous mass movements are important to developing consistent records and interpretations of sediment deposition in High Arctic lakes.