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Using a network of core samples to explore hydroclimatic proxy relationships within the sediments of an alpine, glacier-fed lake

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Spatial and temporal variability of recent lacustrine sedimentation rates are examined for glacier-fed Mud Lake, in the Monashee Mountains of British Columbia. Clastic varve sequences in alpine, glacier-fed environments have been linked elsewhere with temperature (summer, annual), precipitation (autumn, total snowpack), and runoff (glacial, floods), and the use of varved sediments as hydroclimatic proxies is well-developed from single, but rarely multiple, core samples.

In this study, a network of sediment cores (n=63) were extracted using a dense grid-sampling scheme within the 2.5 km2 distal lake basin to assess varve thickness spatially, and through time. A radioisotope profile, sediment traps and repeated coring among multiple years were used to calibrate varve-years with calendar years. Measurements of varve thickness, and sub-annual laminae thickness, were collated among cores and spanned the period 1919 – 2013 AD. The resulting five-dimensional dataset (easting, northing, depth, varve/sub-laminae thickness, time) provides a unique opportunity to explore lacustrine sedimentation. Two clear trends emerge: a general down-lake trend in thickness among most years, which is punctuated by atypical years in which thicker varves appeared in only specific portions of the lake. In the latter case, thick varves appeared either (a) along the north (right-hand) side of the lake where inflow 'hugs' the shoreline, or (b) in the deepest, distal portion of the basin. In both cases, however, atypical varves of type (a) or (b) only punctuate the general down-lake trend in thickness that develops during most years.

The clear implication is that sedimentation patterns, and rates, can (but do not always) differ between years and between points in Mud Lake: there is no 'single optimum' site for a core sample. To illustrate the potential consequences on hydroclimate proxy/inference, we show how the statistical relationships between hydroclimatic records and varve thickness vary spatially. Our hydroclimatic dataset includes homogenized local climatic data available from the Meteorological Service of Canada (MSC) since 1929 (temperature, precipitation, snow course), and discharge data from a river into which Mud Lake drains available from the Water Survey of Canada (WSC) since 1915. Our results show that varve records from different positions within the same lake reveal statistical relationships of markedly differing strength, and differing type, with the same hydroclimatic dataset. We conclude that (1) varve thickness is a key indicator in a hydroclimatic proxy context, but an adjunct consideration should include (2) how varve thickness varies spatially within the basin; varve thickness at a single site is an inconsistent indicator of basin-wide thickness in some years.

Our findings do not complicate the use of varved sediments as hydroclimatic proxies, but highlight that a core network can yield potentially greater insight into a range of hydroclimatic processes in comparison with one, or few, core samples.