
Signature of the Great Acceleration in the varved succession at Crawford Lake, Milton, Ontario, Canada: implications for the Anthropocene as a series/ epoch

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Abstract

Couplets of organic matter capped by calcite precipitated each summer in alkaline surface waters of Crawford Lake accumulate undisturbed below the chemocline of this 23-m-deep meromictic lake in Ontario, Canada. These varves record local impact from an Indigenous agricultural settlement over a 218-year interval around the middle of the last millennium and several hundred years later by colonial land clearing, logging and lumber milling followed by global impact coinciding with the initial major increase in Pu-239+240 (0.0007 ± 0.0002 Bq/g in varves spanning 1948–1951 to 0.0048 ± 0.0006 Bq/g in a sample spanning 1950–1953 CE). This records fallout from nuclear and thermonuclear testing, with strong activity during 1952–1953 CE and levelling associated with the fluctuations in yield, notably testing cessation between November 1958 and February 1961. High activity of Cs-137 also identifies the global peak in this radionuclide in 1963 CE followed by a rapid decline to Nuclear Age background radiation levels in the 1970s. Analysis of samples collected along varve boundaries in several freeze cores and in samples from gravity core CL-19 displays evidence of global atmospheric change (depleted values of $\delta^{15}\text{N}$) and rapidly increased industrial activity (sharply higher concentrations of spheroidal carbonaceous particles/ SCPs) during the Great Acceleration. The unusual hydrology of this meromictic lake, with its well-oxygenated but highly conductive and alkaline bottom waters, preserves the plutonium record, with Pu-239/240 ratios consistent with a global fallout, with exceptional fidelity. Values of F14C > 1 record artificially produced radiocarbon in most samples deposited since the mid-1950s, but the bomb pulse is not well represented in bulk sediment samples due to old carbon in this Silurian dolomitic limestone basin on the Niagara Escarpment.

Lithologically, the SCP-rich sediments deposited in the 1950s through 1960s are dark, with very thin but annually resolvable calcite layers, punctuated by a distinct triplet of calcite

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laminae deposited during the summers of 1956, 1957 and 1958 CE. This is attributed to acidic precipitation resulting from rapid regional industrial expansion at a time of negligible controls on emissions, consistent with the elevated concentrations of heavy metals in these sediments. Reduced precipitation of calcite in the epilimnion of this well-buffered basin, and likely changes in dissolved organic carbon as indirect result of acidic deposition may explain the rapid expansion of the deep-dwelling colonial chrysophyte genus *Synura* at the expense of *Mallomonas* in response to increased depth of the photic zone during the warm summer months. Although changes in authigenic sedimentation and assemblages of siliceous and organic-walled plankton reflect limnologic changes in response to a variety of stressors, this small, isolated lake in rural Ontario has also recorded component signals of the Great Acceleration Event Array which documents a profound shift in the Earth System state during the mid-20th century. Therefore Crawford Lake, along with 11 other reference sections analysed under the aegis of the Anthropocene Working Group, contributes in detail to the stratigraphy of the Anthropocene on a global scale.

Keywords: varved sediments, meromictic lake, Earth Systems, Great Acceleration Event Array, bomb radionuclides, SCPs, siliceous microfossils