Data Article

Isotopic and geochemical data from Barry Lake, Canada: A 900-year record of environmental change

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A B S T R A C T

The data reported here consist of oxygen and hydrogen isotope compositions for 145 modern water samples, and geochemical measurements for gravity cores of sediment, all collected from Barry Lake, a small kettle lake located in Ontario, Canada. The geochemical measurements for the sediment organic matter include organic carbon and total nitrogen isotope compositions, organic carbon and total nitrogen contents and chlorophyll *a* content. The carbon and oxygen isotope compositions of marl contained in these sediments are also reported, along with the calcite and quartz contents of the sediment sample. Mass accumulation rates of total organic carbon, total nitrogen, chlorophyll *a* and calcite are reported. Dating of these sediments shows that they span ∼900 years. The stable isotope compositions of the modern waters and marl are useful to researchers studying how effective moisture (the net of water inputs vs outputs) changed in southern Ontario across the last ∼900 years. Proxies derived from the organic fraction of the lake sediments will be of interest to researchers of small Ontario lakes seeking to contextualize recent increases in primary production related

to eutrophication. A discussion of these data, and a comparison of these data to other cores in the Great Lakes Region, is available in "A 900-year record of effective moisture in the Great Lakes Region" (Doyle et al., 2021).

Specifications Table

Subject	Geochemistry and Petrology
Specific subject area	Isotopic and geochemical data from lake sediments
Type of data	.xlsx files
How data were acquired	145 water samples and three sediment cores (BL-G11-01, BL-G11-02 and BL-G11-07) were collected from Barry Lake (Canada). Modern waters were analyzed using a Thermo Scientific^{TM} Gasbench II or a Los Gatos LGR DT-100 cavity ringdown spectrometer.
	Sediments from BL-G11-02 were analyzed using an Ortec® GWL-120230 High Purity Geranium Gamma Spectrometer (GWL-120230).
	Sediments from BL-G11-01 were analyzed using the following instruments: *(i)* a Geotek® multi-sensor core logger (MSCL-S) equipped with a model MS2E point sensor, *(ii)* a Carlo Erba Fisons® 1108 elemental analyzer, *(iii)* a Costech 4010 Elemental Combustion system (EA) coupled to a Thermo Scientific^{TM} DeltaPLUS XL^{TM} isotope ratio mass spectrometer (IRMS), *(iv)* a VG Micromass MultiPrep® autosampling device coupled to a VG Optima® dual-inlet IRMS, and *(v)* a Rigaku RU-200BVH High Brilliance Rotating Anode X-ray Diffractometer.
	Sediments from BL-G17-01 were analyzed using the following instruments: *(i)* a Geotek® multi-sensor core logger equipped with a point sensor (model MS2E), *(ii)* a Carlo Erba Fisons® 1108 elemental analyzer, *(iii)* a Costech® 4010 Elemental Combustion system (EA) coupled to a Thermo Scientific^{TM} DeltaPLUS XL^{TM} IRMS, *(iv)* a Micromass MultiPrep® device coupled to a VG Optima® dual-inlet IRMS, *(v)* a custom-built High Voltage Engineering (HVE) 3MV tandem accelerator mass spectrometer and *(vi)* a FOSS NIRSystems Inc. 6500 series Rapid Content Analyzer.
Data format	Raw.
Description of data collection	All samples were collected from Barry Lake. The water samples analyzed were collected at various depths in the lake over the time-period 2014–2018. All other data originate from sediment cores collected from the deepest, flattest part of the lake. Cores BL-G11-01 and BL-11-02 were collected in November of 2011, while core BL-G17-01 was collected in July of 2017.
Data source location	Barry Lake, Trent Hills, Ontario, Canada (44.31, -77.92) Waters were collected from various locations within the lake (exact locations are provided in the datasheets associated with this article). Location of core BL-G11-01: 44.308, -77.922 Location of core BL-G11-02: 44.308, -77.922 Location of core BL-G17-01: 44.307, -77.921
Data accessibility	Data provided within the article
Related research article	R.M. Doyle, Z. Liu, J.T. Walker, R. Hladyniuk, K.A Moser, F.J. Longstaffe, 2021. A 900-year record of effective moisture in the Laurentian Great Lakes region, Quat. Sci. Rev. 270, 107174. https://doi.org/10.1016/j.quascirev.2021.107174.

Value of the Data

- These data offer insights into how effective moisture (the net of water inputs vs outputs) and primary production changed in small Ontario lakes over the last ∼900 years.
- These data are useful to researchers investigating the relationships between climate warming and eutrophication and those working to reconstruct hydrologic changes in southern Ontario in the last ∼900 years.
- These data could be compared with other cores collected from nearby locations to identify spatiotemporal patterns in primary production and effective moisture over the last ∼900 years.
- The data could also be used as a baseline of primary production for small Ontario lakes, helping to contextualize recent excursions in primary production associated with eutrophication and climate warming.

1. Data Description

These data include the stable isotope ratios (δ^{18}O and δ^2H) of water collected from Barry Lake and various measurements derived from the sediments contained in cores BL-G11-01, BL-G11-02 and BL-G17-01. For plots of these data, refer to Doyle and colleagues [1]. This dataset has been divided into three files.

BarryLakeWaterData.xlsx – one data table containing the δ^{18}O and δ^2H of 145 water samples collected from Barry Lake. The table also lists the date of sample collection and the location and water depth of sample collection.

BarryLakeCoreData.xlsx – three data tables containing measurements made for cores BL-G11-01, BL-G11-02 and BL-G17-01. The following measurements were obtained for cores BL-G11-01 and BL-G17-01: *(i)* year; *(ii)* sedimentation rates; *(iii)* accumulation rates; *(iv)* dry weights; *(v)* sediment volume; *(vi)* bulk dry density; *(vii)* stable carbon and nitrogen isotope compositions of organic matter (δ^{13}C$_{TOC}$ and δ^{15}N$_{TN}$); *(viii)* percentages of total organic carbon and total nitrogen (%TOC, %TN); *(ix)* ratios of total organic carbon to total nitrogen (TOC:TN); *(x)* stable carbon and oxygen isotope compositions of marl (δ^{13}C$_{marl}$ and δ^{18}O$_{marl}$); *(xi)* percentages of quartz, calcite and organic matter (%Quartz,%Calcite and%OM); *(xii)* magnetic susceptibility (MS); and *(xiii)* mass accumulation rates of carbon, nitrogen and calcite (C-MAR, N-MAR and calcite-MAR). For BL-G17-01, sedimentary chlorophyll *a* (Chl-$a_{(s)}$) contents, and mass accumulation rates of Chl-$a_{(s)}$ (Chl-$a_{(s)}$-MAR), are also reported. For core BL-G11-02, only magnetic susceptibility (MS) is reported.

BarryLakeDating.xlsx – two data tables containing the results of ^{210}Pb-dating of BL-G11-02 and ^{14}C-dating of BL-G17-01, respectively.

2. Experimental Design, Materials and Methods

2.1. Isotopic analysis of water

The δ^2H$_{water}$ and δ^{18}O$_{water}$ of most water samples collected from Barry Lake were analyzed using a Los Gatos LGR DT-100 cavity ringdown spectrometer in the Laboratory for Stable Isotope Science (LSIS) at The University of Western Ontario (Canada). Water samples were removed from a 4 °C refrigerator where they had been stored since collection and set aside until they reached room temperature (∼21 °C). Next, 1 mL of each sample was pipetted into 5 mL glass vials with PTFE septa. Calibration of δ^2H and δ^{18}O to VSMOW was achieved using VSMOW-SLAP calibrated internals standards: LSD (accepted values: δ^2H = -161.8 ‰; δ^{18}O = -22.57 ‰), MID (accepted values: δ^2H = -108.1 ‰; δ^{18}O = -13.08 ‰) and Heaven (accepted values: δ^2H = +88.7 ‰; δ^{18}O = –0.27 ‰). Accuracy and precision were evaluated using the δ^2H and δ^{18}O of laboratory standard

EDT (accepted values: $\delta^2H = -56.0$ ‰; $\delta^{18}O = -7.27$ ‰). The δ^2H and $\delta^{18}O$ for EDT were − 54.8 ± 1.3 ‰ ($n = 9$) and −7.2 ± 0.6 ‰ ($n = 9$), respectively, which compare well with accepted values. LSIS deionized (DI) water analyzed in each session had average standard deviations of δ^2H and $\delta^{18}O$ of ±1.9 ‰ ($n = 5$) and ±0.5 ‰ ($n = 5$), respectively. The average reproducibility of sample duplicates was ±0.6 ‰ ($n = 27$ sample pairs) for δ^2H and ±0.4 ‰ ($n = 27$ sample pairs) for $\delta^{18}O$.

The $\delta^{18}O_{water}$ of 32 water samples was obtained using a Thermo Scientific™ Gasbench II. Prior to the analysis of $\delta^{18}O_{water}$, 1 mL of sample water was injected into septum-sealed glass vials and flushed with 0.3% CO_2 for 5 min [2]. Samples were equilibrated at 35 °C for 24 h in the GasBench® heater block and then transported to the IRMS for analysis. Calibration of $\delta^{18}O$ to VSMOW was achieved using LSD and Heaven, and accuracy and precision were evaluated using laboratory standards EDT and MID. The $\delta^{18}O$ for EDT (-7.4 ± 0.24 ‰, $n = 4$) and MID (-13.0 ± 0.31 ‰; $n = 2$) compare well with accepted values and expected reproducibility. Average sample reproducibility was ± 0.02 ‰ ($n = 3$ sample pairs).

2.2. Dating of cores BL-G11-02 and BL-G17-01

Frozen samples from BL-G11-01 were transported to the Laboratory for the Analysis of Natural and Synthetic Environmental Toxins (LANSET) (Ottawa, Canada) for ^{210}Pb-dating using an Ortec® High Purity Geranium Gamma Spectrometer (Oak Ridge, TN, USA). A constant rate of supply (CRS) model, and the software ScienTissiMe (Barry's Bay, ON, Canada; http://www.scientissime.net/) were used to calculate the ^{210}Pb dates [3]. The contents of ^{214}Pb and ^{241}Am were used to determine background ^{210}Pb. The ^{137}Cs peak (typically peaks ∼1963 CE) was used to verify ^{210}Pb ages.

Five radiocarbon dates were obtained for materials from BL-G17-01, including charcoal, shelly fauna, bulk sediments and woody fragments. Samples were treated according to the protocols described at https://www.ams.uottawa.ca/analytical-methods-radiocarbon-laboratory/. These analyses were performed at the A.E. Lalonde AMS Laboratory (Ottawa, Canada) using a 3MV tandem accelerator mass spectrometer built by High Voltage Engineering (HVE). Coeval charcoal and shelly fauna were analyzed to ensure the absence of a hardwater effect.

2.3. Magnetic susceptibility (MS)

Samples from BL-G11-02 and BL-G17-01 were freeze-dried prior to the analysis of MS. Samples from BL-G11-01 were analyzed wet. The MS of sediments from all cores was determined at the Lake and Reservoir Systems Research Facility (LARS) at the University of Western Ontario using a Geotek® multi-sensor core logger (MSCL) equipped with a point sensor (MS2E).

2.4. Isotopic and elemental analysis of organic matter in sediment cores

Freeze-dried sediments from cores BL-G11-01 and BL-G17-01 were ground and sieved to <300 µm. Sediments designated for the analysis of $\delta^{13}C_{TOC}$ and %TOC underwent acid fumigation following Harris and colleagues [4] prior to analysis. Fractions analysed to determine $\delta^{15}N_{TN}$ and %TN were not acid-fumigated.

The total organic carbon (%TOC) and total nitrogen (%TN) of BL-G11-01 were measured using the Carlo Erba Fisons® 1108 elemental analyzer at the University of Western Ontario's Laboratory for Stable Isotope Science (LSIS). The %TOC and %TN of BL-G17-01 were analyzed concurrently with $\delta^{13}C_{TOC}$ and $\delta^{15}N_{TN}$ at LSIS using a Costech 4010 Elemental Combustion system (EA) coupled to a Thermo Scientific™ DeltaPLUS XL™ isotope ratio mass spectrometer (IRMS) in continuous-flow (He) mode (EA-IRMS). The %TOC and %TN were used to calculate atomic TOC:TN

ratios. Values of $\delta^{13}C_{TOC}$ and $\delta^{15}N_{TN}$ were measured in separate analytical sessions. The $\delta^{13}C_{TOC}$ of sediments deposited after 1850 CE were corrected for the Suess Effect [5].

For BL-G11-01, two standards, Low Organic Content (LOC) soil (accepted values: %TOC = 1.52%; %TN = 0.13 wt.%) and High Organic Content (HOC) soil (accepted values: %TOC = 6.10%; %TN = 0.46%) were used to generate calibration curves for %TOC and %TN measurements. The Peach Leaf standard (SRM number: 1547, accepted values: %TOC = 47.79%; %TN = 2.94%; ISOGEOCHEM communication, https://list.uvm.edu/cgi-bin/wa?A2=isogeochem; b0553eee.0206; Julia Cox, University of Arkansas, H=June 19, 2020,) was also measured in each %TOC and %TN analytical session to evaluate the accuracy and precision of carbon and nitrogen contents. The measured average value of $46.3 \pm 0.19\%$ ($n = 5$) compares well with its accepted values for%TOC, and the measured average value of $2.92 \pm 0.02\%$ ($n = 9$) compares well with its accepted values for%TN. Duplicates were analysed every $\sim$11 samples and had an average reproducibility of $\pm 0.3\%$ ($n = 10$ sample pairs) for TOC and $\pm 0.01\%$ ($n = 7$ sample pairs) for %TN.

The $\delta^{13}C_{TOC}$ and $\delta^{15}N_{TN}$ of BL-G11-01 were calibrated to VPDB and AIR using USGS 40 (accepted values: $\delta^{13}C$ = -26.39 ‰; $\delta^{15}N$ = -4.52 ‰) and USGS 41 (accepted values: $\delta^{13}C$ = +37.63 ‰; $\delta^{15}N$ = +47.57 ‰). For BL-G17-01, USGS 41 was replaced by USGS 41a (accepted values: $\delta^{13}C$ = +36.55 ‰; $\delta^{15}N$ = +47.55 ‰). Internal standard keratin (accepted values: $\delta^{13}C$ = -24.04 ‰; $\delta^{15}N$ = +6.35 ‰) was used to monitor both analytical accuracy and precision. The average obtained for the keratin was -24.04 ± 0.15 ‰ ($n = 39$) for $\delta^{13}C$ and $+6.39 \pm 0.09$ ‰ ($n = 50$) for $\delta^{15}N$, which compares well with its accepted values and expected reproducibility. Sample duplicates were analysed every 10 samples, with an average reproducibility of ± 0.09 ‰ ($n = 8$ sample pairs) for $\delta^{13}C$ and ± 0.06 ‰ ($n = 12$ sample pairs) for $\delta^{15}N$.

For BL-G17-01, two standards, USGS 40 (accepted values:%TOC= 40.7%; %TN= 9.52%) and USGS 41a (accepted values: %TOC= 40.7%; %TN= 9.52%), were used to generate calibration curves for %TOC and %TN measurements. The internal standard keratin (MP Biomedicals Inc., Cat. No. 90211, Lot No. 9966H; average values: %TOC = 48.14 %; TN = 15.10 %) was used to evaluate precision and accuracy of carbon and nitrogen contents. The average %TOC and %TN of keratin was calculated by averaging over 1050 analyses of keratin at LSIS. The measured average value of $48.4 \pm 1.47\%$ ($n = 25$) compares well with its accepted values for%TOC, and the measured average value of $14.8 \pm 0.36\%$ ($n = 26$) compares well with its accepted values for%TN. Duplicates were analysed every $\sim$11 samples and had average reproducibility of $\pm 0.5\%$ ($n = 7$ sample pairs) for%TOC and $\pm 0.04\%$ ($n = 8$ sample pairs) for%TN.

2.5. Isotopic analysis of carbonates in sediment cores

Sediments from BL-G11-01 and BL-G17-01 were inspected for mollusc shells and shell fragments, which were removed by hand-picking prior to further processing. Shells and fragments were placed in an ultrasonic bath filled with distilled water where they were ultrasonicated for 5 min. The samples were then rinsed with deionized water and air-dried. Samples were inspected under the microscope to ensure the absence of organic detritus. The remaining sediment was freeze-dried, ground using a Wig-L-Bug® for 1.5 min, and then sieved to <300 μm.

The $\delta^{13}C_{marl}$, $\delta^{18}O_{marl}$ and percentage of calcite (%calcite) of bulk sediments from BL-G11-01 and BL-G17-01 were obtained at LSIS by reaction with orthophosphoric acid (H_3PO_4) at 90 °C using a Micromass MultiPrep® device coupled to a VG Optima® dual-inlet IRMS. Calibration of $\delta^{13}C$ to VPDB was achieved using NBS 19 (accepted value: $\delta^{13}C$ = +1.95 ‰) and LSVEC (accepted value: $\delta^{13}C$ = -46.6 ‰). Accuracy and precision of analyses were evaluated using the $\delta^{13}C$ of NBS 18 (accepted value: $\delta^{13}C$ = -5.0 ‰) and laboratory standards Suprapur (accepted value: $\delta^{13}C$ = -35.28 ‰) and WS-1 (accepted value: $\delta^{13}C$ = +0.76 ‰). The $\delta^{13}C$ results for NBS 18, Suprapur and WS-1 were -5.04 ± 0.09 ‰ ($n = 27$), -35.57 ± 0.08 ‰ ($n = 13$), and $+0.80 \pm 0.04$ ‰ ($n = 17$), respectively, which compare well with accepted values and expected reproducibility. Like $\delta^{13}C_{TOC}$, $\delta^{13}C_{marl}$ was corrected for the Suess Effect for marl deposited after 1850 CE according to Verberg and colleagues [5]. Calibration of $\delta^{18}O_{marl}$ to VSMOW was achieved us-

ing NBS 19 (accepted value: $\delta^{18}O = +28.65$ ‰) and NBS 18 (accepted value: $\delta^{18}O = +7.20$ ‰). Analytical accuracy and precision were evaluated using Suprapur (accepted value: $+13.25$ ‰) and WS-1 (accepted value: $\delta^{18}O = +26.23$ ‰). The $\delta^{18}O$ results for Suprapur and WS-1 were $+13.25 \pm 0.11$ ‰ ($n = 13$) and $+26.29 \pm 0.10$ ‰ ($n = 17$), respectively, which compare well with accepted values and expected reproducibility. The pressure transducer reading of the Multiprep® device, which varies directly with the amount of calcite in the sample, was used to estimate the percentage of calcite (%calcite) throughout the cores, and in some cases cross-checked using powder X-ray diffraction (*p*XRD).

2.6. Analysis of sedimentary chlorophyll-a (Chl-a$_{(s)}$) and its derivatives

Sediments from BL-G17-01 were ground until they passed through a 125 μm mesh. Sedimentary chlorophyll-*a* and its derivatives of these sediments were measured by visible reflectance spectroscopy (VWRS) (400– 2500 nm) using the spectroradiometer (Rapid Content Analyzer) at the Paleoecological Environmental Assessment and Research Laboratory (PEARL, Queen's University). The peak area between 650 and 700 nm was imported into Eq. (1) to infer the concentration of Chl-a(s) [6]:

$$\text{Chlorophyll a} + \text{derivatives} = 0.0919 \times \text{peak area 650-700 nm} + 0.0011 \qquad (1)$$

2.7. Sediment mineralogy

Shell fragments were hand-picked from the freeze-dried sediments of BL-G11-01. These sediments were then ground to a find powder (<65 μm) and homogenised using a ceramic mortar and rubber pestle. Next, ~30 mg of this sediment was mounted onto an Al-backpack holder. Powder X-ray Diffraction (*p*XRD) was then performed on these sediments at LSIS using a Rigaku High Brilliance Rotating Anode X-ray Diffractometer equipped with a graphite monochromator, using Co Kα radiation produced by a current of 45 mA and a potential of 160 kV.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that have or could be perceived to have influenced the work reported in this article.

CRediT Author Statement

R.M. Doyle: Conceptualization, Investigation, Writing – original draft, Writing – review & editing, Methodology, Validation, Formal analysis; **Z. Liu:** Conceptualization, Investigation, Methodology, Formal analysis; **J.T. Walker:** Investigation; **R. Hladyniuk:** Conceptualization, Investigation; **K.A. Moser:** Supervision, Conceptualization, Writing – review & editing; **F.J. Longstaffe:** Supervision, Conceptualization, Writing – review & editing, Resources, Project administration, Funding acquisition.

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Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2022.107880.

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