96-30

S19

NATIONAL WATER RESEARCH INSTITUTE

INSTITUT NATIONAL de RECHERCHE sur les EAUX

^{210}Pb dating of sediments from the St. Lawrence River (Core 091, Station PILON), Ontario

L.J. Turner

NWRI Contribution 96-30

^{210}Pb dating of sediments from the St. Lawrence River (Core 091, Station PILON), Ontario.

L.J. Turner

CONTRIBUTION 96-30
July 1996

National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario L7R 4A6

Turner, L.J., 1996. ^{210}Pb dating of sediments from the St. Lawrence River (Core 091, Station PILON), Ontario. National Water Research Institute, Burlington, Ontario. NWRI CONTRIBUTION 96-30, 27p.

Summary

A sediment core was dated from the St. Lawrence River, Ontario. The ^{210}Pb profile of the sediment core was used to determine the chronological age of the sediment as well as the sedimentation rate. The mean specific gravity was determined to be 2.574 $g \cdot cm^{-3}$. The sedimentation rate was calculated to be 0.39 $cm \cdot yr^{-1}$ for core 091 using a CIC model. The average mass sedimentation rate was determined to be 0.12 $g \cdot cm^{-2} \cdot yr^{-1}$ using the CIC1 model, 0.14 $g \cdot cm^{-2} \cdot yr^{-1}$ using the CIC2 model, and 0.15 ± 0.079 $g \cdot cm^{-2} \cdot yr^{-1}$ using the CRS model.

Porosity and activity profiles indicate changes in sediment composition throughout the core. Compositional changes indicate modifications in source of materials which may be accompanied by variations in accumulation rate. CRS results indicate a variable sedimentation rate for this core.

Results from core 091 analyses must be used with caution. CIC and CRS analyses of core 091 activity data were performed under the assumption that the ^{210}Pb activity profile reflected activity decay, not variability in sorptive capacity due to sediment compositional changes. The validity of the assumption for core 091 is not known.

INTRODUCTION

In this study, a core (091) taken from the St. Lawrence River (station PILON), was dated using a ^{210}Pb method (Eakins and Morrison, 1978). The core was collected by Technological Operations personnel (National Water Research Institute, Burlington) and submitted for analysis by H. Biberhofer (CCIW, NWRI, Study LTSS-95). Other eastern Canadian cores have been dated using this method (Turner and Delorme, 1988a-b, 1989a-g, 1990, 1992; Turner, 1990a-e, 1991a-g, 1992a-c, 1993a-d, 1994a-b, 1995a-g, 1996a-c).

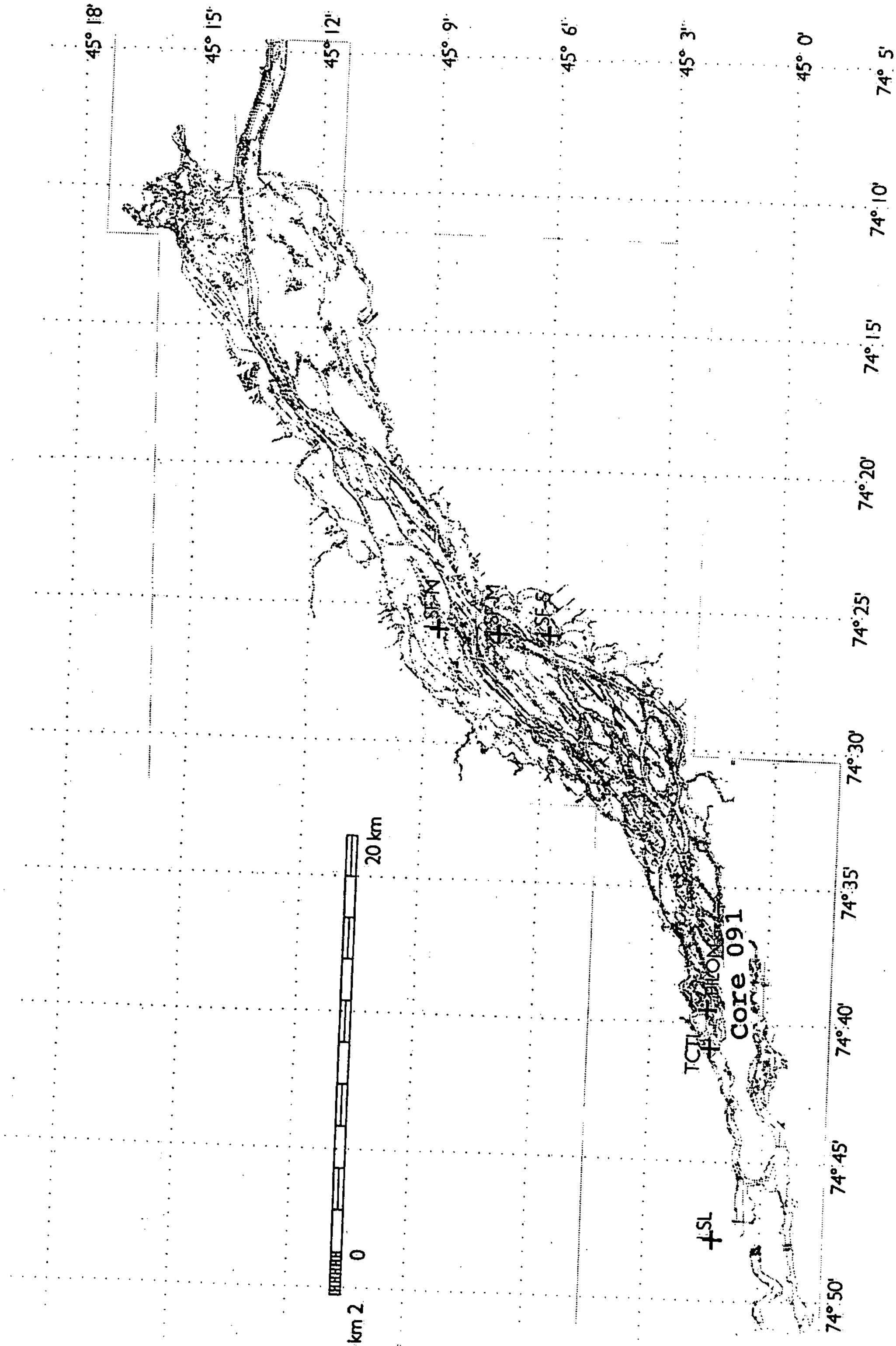
LOCATION AND CORE PREPARATION

The location of the sample site from which the core was taken (Station PILON; 45.03°N, 74.66°W) is shown in Figure 1. On February 17, 1996, the St. Lawrence River was cored using a lightweight corer (10.16 cm diameter) at a water depth of 12.6 m. Core 091 was transported to Burlington, Ontario and placed in cold storage. On March 29, 1996, the core was subsectioned into 1-cm intervals giving thirty-six (36) samples. The samples were weighed, freeze-dried, and then re-weighed. These weights were used to calculate porosity and the uncompacted depth (see Appendices A - B, Delorme, 1991).

A plot of porosity versus uncompacted mid-depth and cumulative dry weight for core 091 is shown in Figure 2. The porosity profile illustrates changes in lithology throughout the length of the core. Numerous shells can be found near the sediment/water interface. Decreases in porosity with depth are accompanied by increases in particle size (sand). One region (samples 12-22) is typified by organic debris (wood chips etc) mixed with sand. The region of lowest porosity contains pebbles.

Specific Gravity was determined using an automated Accupyc pycnometer (Micromeritics, 1992). Mean specific gravity for the sediments of core 091 is 2.574 ± 0.077 $g{\cdot}cm^{-3}$ based on 10 samples and 49 determinations (see Appendix C this report).

Figure 1. Location map of the sampling site for core 091, St. Lawrence River, Ontario.



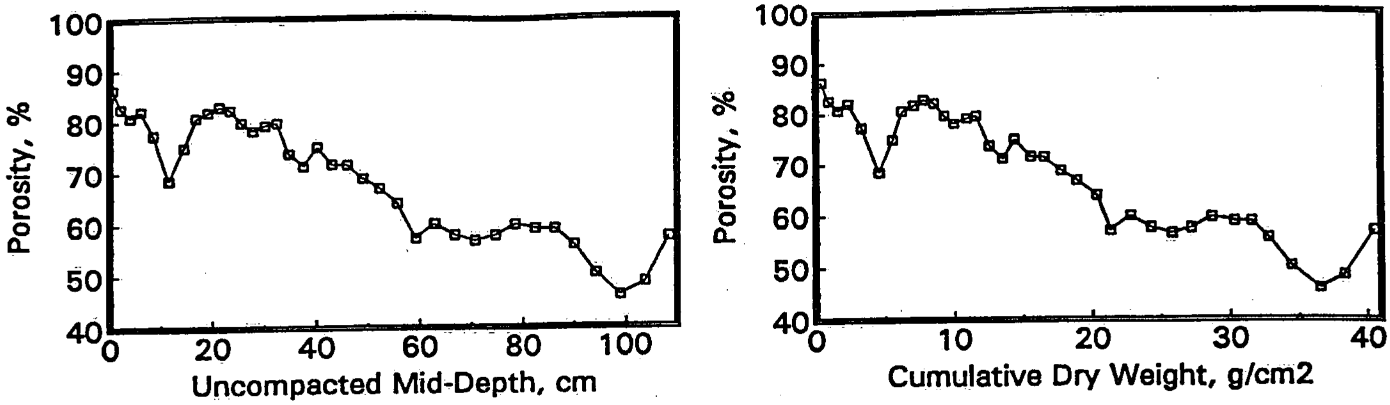


Figure 2. Distribution of porosity with uncompacted mid-depth or cumulative dry weight for core 091.

METHOD

Laboratory Procedures

Homogeneous portions of 24 samples (Table 1, including 2 sets of replicates) from core 091 were treated using a variation on the Eakins and Morrison (1978) polonium distillation procedure. Details of the laboratory procedure are found in a laboratory manual (Turner, 1990).

Following grinding and homogenizing, 1 g (upper core) to 3 g (lower core) of sediment were treated with concentrated HCl to remove carbonate materials, then mixed with approximately 10 dpm ml^{-1} of ^{209}Po spike in a test tube. The ^{209}Po spike was prepared on September 6, 1991 at 6.07 dpm/ml activity. The test tube and contents were then placed in an oven at 110°C until dry.

After cooling, glass wool plugs (one to hold the sediment at the bottom of the tube, one dampened to catch polonium at the opening of the tube) were inserted, then the tubes were placed into a tube furnace and heated to 700°C for ½ hr to distill the polonium from the sediments. At this temperature, polonium passes easily from the sediment, through the dry wool plug and does not condense until reaching the wet wool plug outside the furnace.

After cooling, the tube was cut, and the upper part containing the damp glass wool (condenser) was digested in concentrated HNO_3 under reflux (to destroy organic material). The residue was then filtered and the filtrate boiled down and digested with two HCl treatments to remove any remaining traces of HNO_3.

The polonium was then plated from the remaining solution onto a finely polished silver disk. The disk was counted in an alpha spectrometer. ^{209}Po was identified by its 4.88 MeV alpha particle, and ^{210}Po by its 5.305 MeV alpha particle. The ^{210}Po counts obtained from the spectrometer were compared to the ^{209}Po counts (of known activity) to determine the activity of ^{210}Po in the sediment sample.

Sediment Dating Theory

Dating of lacustrine sediments has been actively pursued for several decades (Robbins and Edgington, 1975; Matsumoto, 1975; Appleby and Oldfield, 1978; and Farmer, 1978). Sedimentation rates are derived using either the CIC (constant initial concentration of unsupported ^{210}Pb; Robbins and Edgington, 1975; Matsumoto, 1975) or the CRS (constant rate of supply; Appleby and Oldfield, 1978) model. The CIC model assumes a constant sedimentation rate over the time period in which unsupported ^{210}Pb is measured. The CRS model assumes a variable sedimentation rate. Both models assume a constant flux of unsupported ^{210}Pb to the sediment/water interface. Depth can be corrected for sediment compaction in the CIC model using sediment porosity measurements, otherwise cumulative dry weight is used. Sediment compaction is accounted for in the CRS model by dealing with cumulative dry weight instead of sediment depth.

The profile of ^{210}Pb in a sediment core can be described as follows:

$$A_{Tx} = (A_{Uo})e^{-\lambda t} + A' \qquad (1a)$$

where A_{Tx} is the total activity of ^{210}Pb in the sample in $pCi \cdot g^{-1}$ dry wt at depth x, and of age t.

A' is the activity of ^{210}Pb supported by ^{226}Ra in $pCi \cdot g^{-1}$ dry wt (represented by constant ^{210}Po activities attained at depth),

A_{Uo} is the unsupported activity of ^{210}Pb at the sediment/water interface in $pCi \cdot g^{-1}$ dry wt,

λ is the radioactive decay constant for ^{210}Pb ($0.693/22.26\ yr^{-1} = 0.0311\ yr^{-1}$),

And since $A_{Ux} = A_{Tx} - A'$ then $A_{Ux} = (A_{Uo})e^{-\lambda t}$ (1b)

where A_{Ux} is the unsupported activity of ^{210}Pb in the sample in $pCi \cdot g^{-1}$ dry wt at depth x,

The Constant Initial Concentration (CIC) Model:

In the following derivations, equations which refer to the usage of cumulative dry weight instead of uncompacted depth in the CIC model are designated with an 'a'.

In the CIC model, uncompacted mid-depth, z, can be used instead of natural depth, x, to compensate for sediment compaction. Otherwise cumulative dry weight is used. The uncompacted mid-depth is calculated from uncompacted thickness (Delorme 1991).

$$t_{ui} = \{(\phi_o - \phi_i)/(1 - \phi_o)\} + (TV_i * V_q) \quad (2)$$

where t_{ui} is the uncompacted thickness of the i^{th} sample,

ϕ_i is the porosity of the i^{th} sample expressed as a percentage,

ϕ_o is the porosity at the sediment-water interface calculated by regressing the top four sample porosities (ϕ_i) against natural mid-depth, and ϕ_o = y intercept,

TV_i is the total volume of the i^{th} sample,

V_q is the volume of a cylinder 1 cm high and surface area equal to either the inside of the core tube or the stainless steel extrusion ring, whichever is appropriate.

The CIC model assumes a constant sedimentation rate (or mass sedimentation rate) over the time period in which unsupported ^{210}Pb is measured, thus

$$t = z/S_o \quad (3)$$

$$t = c/\omega \quad (3a)$$

where S_o is the sedimentation rate in $cm \cdot yr^{-1}$ at the sediment/water interface,

z is uncompacted mid-depth,

c in cumulative dry weight in $g \cdot cm^{-2}$,

ω is the mass sedimentation rate in $g \cdot cm^{-2} \cdot yr^{-1}$.

The total ^{210}Pb activity at the sediment water interface is:

$$A_{To} = (P/\omega) \quad (4)$$

where P is the flux of ^{210}Pb at the sediment water interface in $pCi \cdot cm^{-2} \cdot yr^{-1}$, (assumed constant).

Substituting equations (3) [and (3a)] and (4) into equation (1a) gives:

$$A_{Tz} = (P/\omega)e^{-z\lambda/S_o} + A' \quad (5)$$

or

$$A_{Tx} = (P/\omega)e^{-c\lambda/\omega} + A' \quad (5a)$$

Equation (5) or [5(a)] can be simplified using natural logarithms:

$$\ln(A_{Tz} - A') = \ln(P/\omega) - (\lambda/S_o)z \quad (6)$$

$$\ln(A_{Tx} - A') = \ln(P/\omega) - (\lambda/\omega)c \quad (6a)$$

The form of the equation is $y = b + (m)\ x$

A graphical solution for P/ω (the y-intercept) and λ/S_o [or (λ/ω)] (the slope of the line) is possible from a plot of x and y {z vs $\ln(A_z - A')$} [or c vs $\ln(A_x - A')$] (see Figure 4). As λ is known, then S_o [or ω] can be calculated.

$$S_o = \lambda/\text{slope} = \lambda/(m) \quad (7)$$

$$\omega = \lambda/\text{slope} = \lambda/(m) \quad (7a)$$

When using uncompacted depth, the mass sedimentation rate ω $(g \cdot cm^{-2} \cdot yr^{-1})$ is represented by:

$$\omega = S_o\ (1 - \phi_o)\ \rho_s = S_i\ (1 - \phi_i)\ \rho_s \quad (8)$$

where ρ_s is the density of the solid phase of the sample (assumed constant),

S_i is the sedimentation rate $(cm \cdot yr^{-1})$ at a given uncompacted mid-depth z.

The flux at the sediment/water interface P $(pCi \cdot cm^{-2} \cdot yr^{-1})$ can be calculated from the y-intercept and mass sedimentation rate.

$$P = \omega\ (e^{b}) \qquad (9)$$

Using equation (6) [or (6a)] the time 't' in years since the sample was deposited is given by:

$$t = \frac{\ln\ (A_{Tz} - A') - \ln(P/\omega)}{(-\lambda)} = \frac{z}{S_o} \qquad (10)$$

or

$$t = \frac{\ln\ (A_{Tx} - A') - \ln(P/\omega)}{(-\lambda)} = \frac{c}{\omega} \qquad (10ai)$$

which can be written as:

$$t = -\frac{1}{\lambda}\ \ln \frac{(A_{Tz}-A')}{A_{To}} = \frac{z}{S_o} \text{ or } = \frac{c}{\omega} \qquad (10aii)$$

The uncompacted mid-depth (cm) divided by the sedimentation rate ($cm \cdot yr^{-1}$) [or cumulative dry weight, ($g \cdot cm^{-2}$) divided by mass sedimentation rate ($g \cdot cm^{-2} \cdot yr^{-1}$)] gives t.

<u>The Constant Rate of Supply (CRS) Model</u>:

Since the CRS model assumes a constant rate of supply, then

$$P = A_{Ui} * \omega_t \qquad (11)$$

where P is the flux of ^{210}Pb at the sediment water interface in $pCi \cdot cm^{-2} \cdot yr^{-1}$, (assumed constant)

A_{Ui} is the initial activity of unsupported ^{210}Pb in sediment of age t

ω_t is the dry Mass Sedimentation Rate ($g \cdot cm^{-2} \cdot yr^{-1}$) at time t.

Sediment laid down during time period δt occupies a layer of thickness (δx):

$$\delta x = \frac{\omega_t}{\rho_x}\ \delta t \qquad (12)$$

were ρ_x is the dry mass/unit wet volume of the sample ($g \cdot cm^{-3}$) at depth x.

$$\rho_x = \frac{d\omega}{dx} \qquad (13)$$

The rate of change of depth is

$$x' = \frac{\omega}{\rho_x} \tag{14}$$

where ′ denotes differentiation with regards to t.

and $$x' \rho_x = \omega = x'_o \rho_o \tag{15}$$

Equation (15) combines with (1b) to give

$$x' \rho_x A_{Ux} = x'_o \rho_o (A_{Uo}) e^{-\lambda t} \tag{16}$$

Let $$B(x) = \int_x^{\infty} \rho_x * A_{Ux}\, dx = \int_x^{\infty} A_{Ux}\, d\omega \tag{17}$$

represent the total residual or cumulative unsupported ^{210}Pb beneath sediments of depth x,

and $$B(0) = \int_0^{\infty} \rho_o * A_{Uo}\, dx = \int_0^{\infty} A_{Uo}\, d\omega \tag{18}$$

represent the total residual unsupported ^{210}Pb in the sediment column, then

$$B(x) = B(0) e^{-\lambda t} \tag{19}$$

The age of layer at depth x is thus:

$$t = - \frac{1}{\lambda} \ln \frac{B(x)}{B(0)} \tag{20}$$

where B(x) and B(0) are calculated by direct numerical integration of the ^{210}Pb profile (the plot of unsupported activity versus cumulative dry weight).

The mass sedimentation rate is calculated by dividing the change in the mid-sample cumulative dry weight by the difference of time in years for the sample analyzed.

The mean ^{210}Pb supply rate (flux) is calculated from

$$P = \lambda B(0) \tag{21}$$

Quality Assurance/Quality Control

Quality Assurance: Collection and Preparation of Core Samples

The samples for core 091 were collected using a lightweight corer.

When the core was extruded, the outer smeared portion was removed using a stainless steel ring to prevent contamination of sediments from above (following the procedure outlined by Delorme, 1991). The samples were freeze-dried using a standard procedure. Minimum loss of water from each sample was achieved by keeping tight lids on the vials before weighing and freeze drying. There was no transfer of sediments from the vials until freeze-drying was complete and the dry weights obtained.

Test runs for quality control on the alpha spectrometry equipment were last done in June, 1996.

Quality Control: Contamination and Method Checks

Blanks (no sample, no spike), were run through the same analytical procedures as samples, to determine if there was contamination from analytical reagents. Blanks, prepared at the same time as the sediment samples, exhibited a background activity of 0.03 dpm when run in all detectors, an activity comparable to empty sample holders.
Yield tracer solutions (no sediment sample) were also run through the analytical procedure. No counts above background were detectable in the ^{210}Po region of the spectra for disks prepared using only the spike (no sample), indicating no polonium (^{210}Po) contamination in the analyses from spike solutions.

Quality Assurance: System Checks

The alpha spectrometer has been monitored since May of 1988. Sample chambers are examined on a monthly basis for contamination. Empty sample holders give a background count rate of 0.01 dpm which equals the equipment specifications.

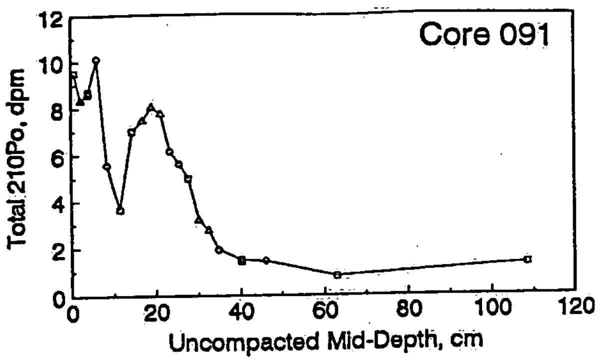
RESULTS

Table 1 lists the ^{210}Po activities for the 24 samples prepared for core 091. Figure 3 depicts the ^{210}Po activity profile with depth and cumulative dry weight. The symbols used in figure 3 indicate which detector was used during sample analysis. Circles represent detector 3, triangles represent detector 2, and squares represent detector 1.

Table 1. Activity of ^{210}Po in Core 091 Sediment.

Sample	Cum. Dry Wt. g/cm2	Uncomp. Mid Depth cm	210Po dpm/g	DET No.
1	0.39	0.65	9.5	1
2	0.92	2.14	8.3	2
3	1.60	4.01	8.6 ± 0.1	1/2/3
3R	1.60	4.01	8.7 ± 0.6	1/2/3
3R2	1.60	4.01	8.7 ± 0.2	1/2/3
4	2.33	6.10	10.1	3
5	3.32	8.50	5.6	3
6	4.57	11.47	3.6	1
7	5.55	14.47	7.0	1
8	6.22	16.85	7.4	2
9	7.04	19.05	8.0	2
10	7.76	21.31	7.7	2
11	8.48	23.44	6.1	3
12	9.25	25.61	5.6	3
13	9.97	27.81	5.0	1
14	10.89	30.16	3.1	2
15	11.58	32.47	2.7	2
16	12.54	34.87	1.9	3
18	14.35	40.27	1.5 ± 0.1	1/2/3
18R	14.35	40.27	1.5 ± 0.0	1/2/3
18R2	14.35	40.27	1.4 ± 0.0	1/2/3
20	16.49	46.01	1.4	3
25	22.78	62.90	0.8	1
36	40.50	108.44	1.3	1

The profile of core 091 has an area of depressed activity encompassing samples 5-7. This area also exhibits slightly depressed porosity (Figure 2). At first glance, slumping of sediment was suspected. However, examination of sediment composition proved slumping not to be present. The shell content of core 091 sediment increased in the depressed activity region, maximizing in sample 6. Examination of sediments below sample 10 reveals an influx of organic debris/wood particles not detected in the upper samples. The organic debris increases with depth until sample 22, where it disappears as the composition changes to sand. Caution must be exercised when using this activity data as the activity profile



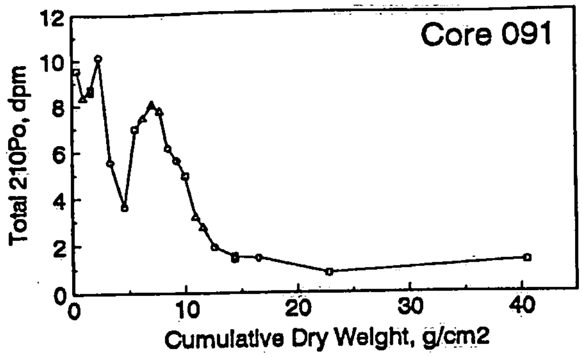


Figure 3. Distribution of Total ^{210}Po activity in dpm·g^{-1} in relation to uncompacted mid-depth and cumulative dry weight for core 091.

of core 091 may reflect variability in sorptive capacity due to changing sediment composition more than the decay in activity.

Reproducibility of Results

Two slices from core 091 were chosen to have the analysis for ^{210}Po repeated. These are listed in Table 2. The ^{210}Po activities are given in Table 1.

Table 2 Reproducibility of Core 091 analyses.

Core	Sample	Uncompacted Mid Depth	^{210}Po activity Mean ±Std Deviation
091	3	4.0	8.7 ± 0.1
	18	40.3	1.5 ± 0.1

^{210}Pb Analysis of St. Lawrence River core 091, using the CIC model.

Analysis of core 091 activity data using CIC dating models is being performed under the assumption that the ^{210}Pb activity profile reflects activity decay, not variable sorption due to changes in sediment composition.

For the first CIC model, the unsupported activity is plotted against uncompacted mid-depth (Figure 4) using the expanded equation (6). Based on the graphical solution, the y-intercept is $\ln(P/\omega) = 2.4497$ and the slope of the line (λ/S_0) is -0.0794 (see Appendix D). Samples 4 to 16 were used to calculate an average sedimentation rate of 0.39 cm·yr^{-1}, an average mass sedimentation rate of 0.12 g·cm^{-2}·yr^{-1} and a flux of 1.37 pCi·cm^{-2}·yr^{-1}. The mean dates calculated for each core section, based on a division of the uncompacted mid-depth by the sedimentation rate (equation 3), are given in Appendix G. The '±' values are two standard deviations

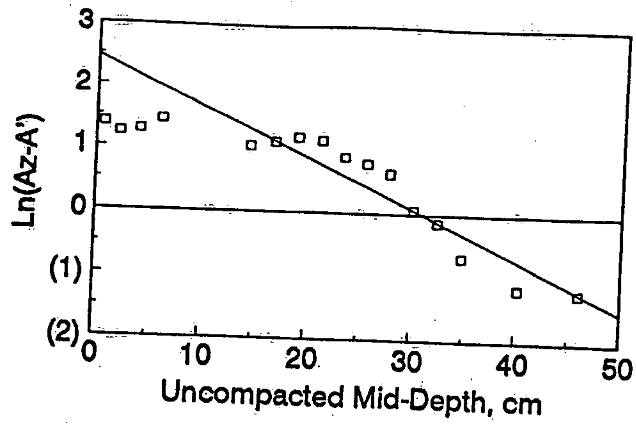


Figure 4. The distribution of uncompacted mid-depth against $\ln(A_z - A')$ for core 091. The y intercept of the regression line = 2.4497, the slope = -0.0794.

based on data calculated for the top, bottom, and mid-depth of the sample.

For the second CIC model, the unsupported activity is plotted against cumulative dry weight (Figure 5) using the expanded equation (6a). Based on the graphical solution, the y-intercept is $\ln(P/\omega) = 2.4345$ and the slope of the line (λ/ω) is -0.2275 (see Appendix E). Samples 4 to 16 were used to calculate an average mass sedimentation rate of 0.14 $g \cdot cm^{-2} \cdot yr^{-1}$ and a flux of 1.56 $pCi \cdot cm^{-2} \cdot yr^{-1}$. The dates calculated for each core section, based on a division of the cumulative dry weight by the mass sedimentation rate (equation 3a) are given in Appendix G. The '±' values are two standard deviations based on data calculated for the top, bottom, and mid-section of the sample.

Ideally, the CIC1 and CIC2 models should give almost identical results. A difference in the mass sedimentation rates and

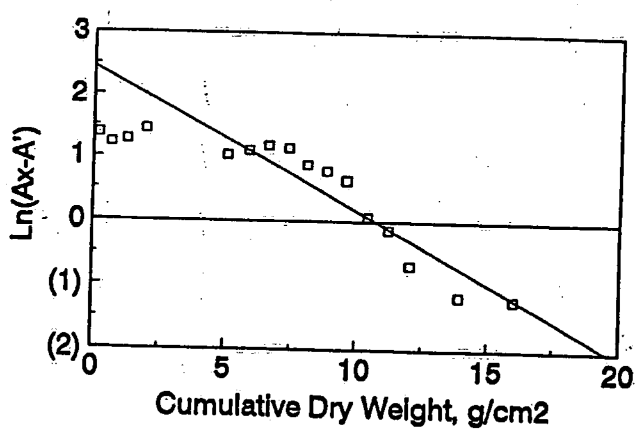


Figure 5. The distribution of cumulative dry weight against $\ln(A_x - A')$ for core 091. The y intercept of the regression line = 2.4345, the slope = -0.2275.

atmospheric fluxes determined from the CIC1 and CIC2 models may indicate a problem in the calculation of uncompacted mid-depth. It may indicate a change in lithology that was not completely accounted for by porosity or specific gravity measurements.
A comparison of the mass sedimentation and atmospheric flux rates for this core shows fair agreement.

^{210}Pb Analysis of St. Lawrence River core 091, using the CRS model.

Analysis of core 091 activity data using CRS dating model is being performed under the assumption that the ^{210}Pb activity profile reflects activity decay, not variable sorption due to compositional change.
For the CRS model, the unsupported activity is plotted against cumulative dry weight (Figure 3). The profile is integrated to determine B(0) and B(x) and calculate time (see Appendix F) according to equation 20. Since not all samples were analyzed for ^{210}Pb activity, a multiple regression analysis was performed to obtain the dates for each core section as given in Appendix G. Samples 1 to 15 were used in this example to calculate an average mass sedimentation rate of 0.15 ± 0.079 $g \cdot cm^{-2} \cdot yr^{-1}$ and flux of 1.07 $pCi \cdot cm^{-2} \cdot yr^{-1}$. The variation in mass sedimentation rate in core 091 is illustrated in figure 6.

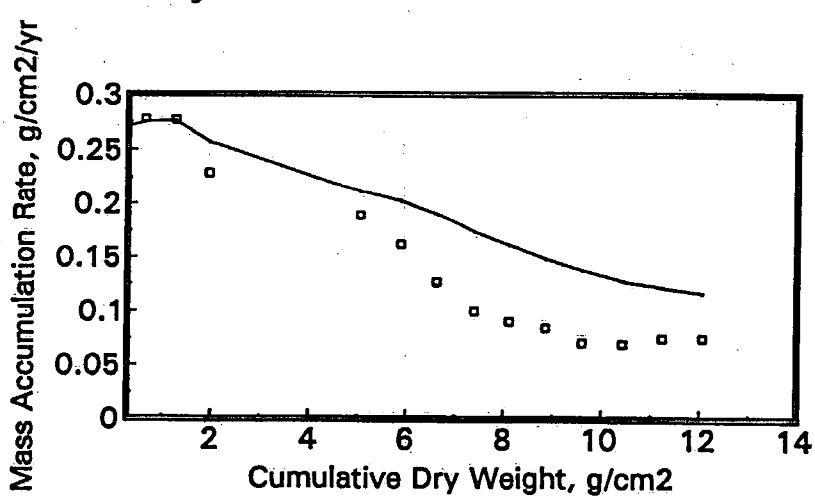


Figure 6. Plot of mass sedimentation rate versus cumulative dry weight for core 091. Points represent mass sedimentation rates determined from integrated area defined by activity and cumulative dry weight for the sample, the line represents the running mean of the mass sedimentation rate.

Comparison of CIC and CRS ^{210}Pb Analysis of Core 091.

Table 3 lists mass sedimentation and atmospheric flux rates as calculated from the CIC and CRS models. The mass sedimentation rates are in fair agreement. The flux rates do not agree as closely. The year corresponding to individual core sections (Appendix G) as determined by the CIC and CRS models are plotted against cumulative dry weight in Figure 7. Figure 7 shows a very close agreement between the two CIC models. There is some agreement between the CIC and CRS models in the upper reaches of the core, and towards the bottom of the core. A large area of discrepancy occurs midcore. The disagreement is likely caused by the variable sedimentation rate indicated by the CRS model as illustrated in Figure 6. Variability in sedimentation rate is expected when core composition fluctuates as in core 091. This evidence indicates that the assumption of a 'constant sedimentation rate' for the CIC model was an unacceptable one.

Table 3. Summary of Mass Sedimentation Rate and Atmospheric Flux.

Model	Average Mass Sedimentation Rate $g \cdot cm^{-2} \cdot yr^{-1}$	Atmospheric Flux $pCi \cdot cm^{-2} \cdot yr^{-1}$
CIC1	0.12	1.37
CIC2	0.14	1.56
CRS	0.15 ± 0.079*	1.07

* Based on incremental mass sedimentation rates (Appendix F)

Analysis of core 091 activity data using CIC and CRS dating models was performed assuming that the ^{210}Pb activity profile reflects activity decay, not variable sorption due to sediment compositional changes. Results from the analyses must be used with caution. The validity of the assumption is not known.

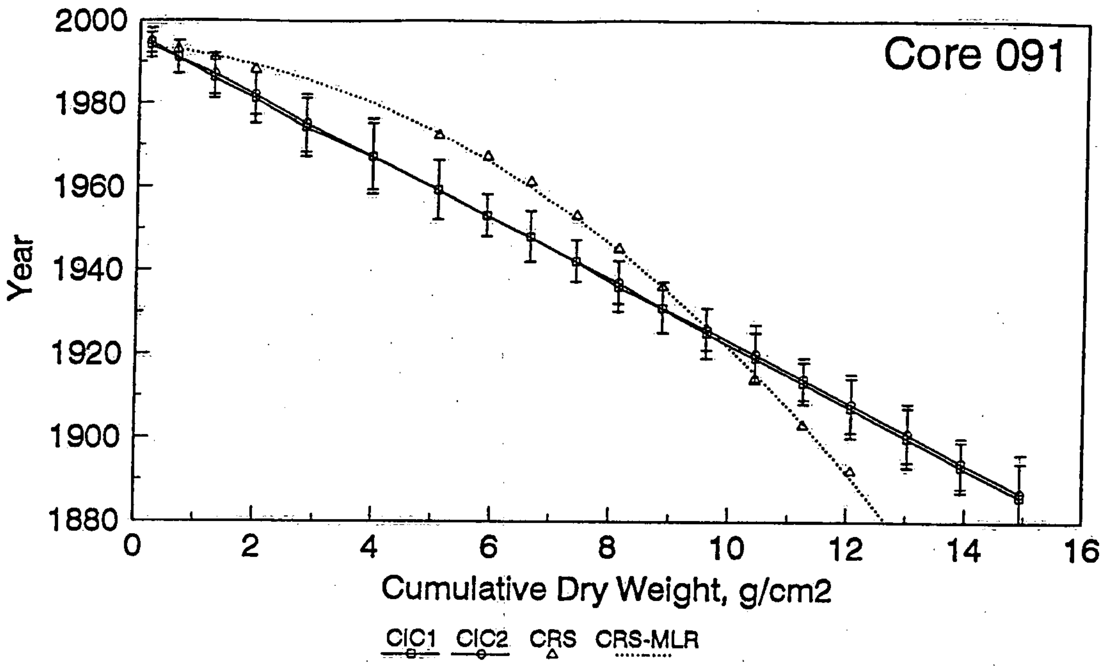


Figure 7. Plot of the Year determined from CIC (squares and circles)/CRS (triangles) models versus cumulative dry weight for St. Lawrence River Core 091.

REFERENCES

Appleby, P.G. and F. Oldfield. 1978. The calculation of ^{210}Pb dates assuming a constant rate of supply of unsupported ^{210}Pb to the sediment. Catena 5:1-8

Delorme, L.D. 1991. The preparation of lacustrine sediment samples from cores for use in dating and paleolimnology. National Water Research Institute, Burlington, Ontario, Contribution 92-188, 18p.

Eakins, J.D. and R.T. Morrison. 1978. A new procedure for determination of lead-210 in lake and marine sediments. International Journal of Applied Radiation and Isotopes 29:531-536.

Farmer, J.G. 1978. The determination of sedimentation rates in Lake Ontario using the ^{210}Pb dating method. Canadian Journal of Earth Sciences 15:431-437.

Matsumoto, E. 1975. ^{210}Pb geochronology of sediments from Lake Shinji. Geochemical Journal 9:167-172.

Micromeritics 1992. Automated Accupyc pycnometer 1330, for determining skeletal density and volume of powders, porous materials, and irregularly shaped solid objects. Operators Manual V2.01, Micromeritics Instrument Corporation, Norcross, Georgia.

Oldfield, F. and P.G. Appleby. 1984. Empirical testing of ^{210}Pb dating models for lake sediments IN Lake Sediments and Environmental History (Eds. E.Y. Harworth and J.W.G. Lund). University of Minnesota Press, Minneapolis. pp 93-124.

Robbins, J.A. and D.N. Edgington. 1975. Determination of recent sedimentation rates in Lake Michigan using Pb-210 and Cs-137. Geochimica et Cosmochimica Acta 39:285-304.

Turner, L.J. 1996a. ^{210}Pb dating of lacustrine sediments from Lake Erie (Core 083, Station 351), Ontario. National Water Research Institute, Burlington, Ontario. NWRI Contribution 96-02, 31p.

Turner, L.J., 1996b. ^{210}Pb dating of sediments from the St. Lawrence River (Core 087, Station TCT1), Ontario. National Water Research Institute, Burlington, Ontario. NWRI CONTRIBUTION 96-28, 27p.

Turner, L.J., 1996c. ^{210}Pb dating of sediments from Lake St. Lawrence (Core 087, Station LSL), Ontario. National Water Research Institute, Burlington, Ontario. NWRI CONTRIBUTION 96-29, 27p.

Turner, L.J. 1995a. ^{210}Pb dating of lacustrine sediments from Irondequoit Bay, Lake Ontario (Core 065, Station IB-94-2), New York. National Water Research Institute, Burlington, Ontario. NWRI Contribution 95-100, 30p.

Turner, L.J. 1995b. ^{210}Pb dating of lacustrine sediments from Hamilton Harbour (Core 066, Station JPC94HHD4), Lake Ontario. National Water Research Institute, Burlington, Ontario. NWRI Contribution 95-108, 24p.

Turner, L.J. 1995c. ^{210}Pb dating of lacustrine sediments from Mud Lake (Core 068), Ontario. National Water Research Institute, Burlington, Ontario. NWRI Contribution 95-109, 37p.

Turner, L.J. 1995d. ^{210}Pb dating of lacustrine sediments from Preston Lake (Core 074), Ontario. National Water Research Institute, Burlington, Ontario. NWRI Contribution 95-110, 32p.

Turner, L.J. 1995e. ^{210}Pb dating of lacustrine sediments from Hamilton Harbour (Core 071, Station HH93-2; Core 072, Station HH93-8; Core 073, and Station HH93-11), Lake Ontario. National Water

Research Institute, Burlington, Ontario. NWRI Contribution 95-113, 35p.

Turner, L.J. 1995f. ^{210}Pb dating of lacustrine sediments from Lake Erie (Core 077, Station 348), Ontario. National Water Research Institute, Burlington, Ontario. NWRI Contribution 95-119, 27p.

Turner, L.J. 1995g. ^{210}Pb dating of lacustrine sediments from Lake Erie (Core 082, Station 348), Ontario. National Water Research Institute, Burlington, Ontario. NWRI Contribution 95-277, 27p.

Turner, L.J. 1994a. ^{210}Pb dating of lacustrine sediments from Lake Erie (Core 055, Station 84-1), Ontario. National Water Research Institute, Burlington, Ontario. NWRI Contribution 94-116, 25p.

Turner, L.J. 1994b. ^{210}Pb dating of lacustrine sediments from Big Creek Marsh (Core 058, Station 173) and Coletta Bay (Core 059, Station 174), in Inner Bay, Lake Erie, Ontario. National Water Research Institute, Burlington, Ontario. NWRI Contribution 94-127, 32p.

Turner, L.J. 1993a. ^{210}Pb dating of lacustrine sediments from Hamilton Harbour (Core 047, Station 37-1; Core 051, Station 22-D; and Core 052, Station 20-C), Lake Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-TN-93-42, 41p.

Turner, L.J. 1993b. ^{210}Pb dating of sediments from Malden Creek (Core 053) and Muddy Creek (Core 054), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-TN-93-43, 16p.

Turner, L.J. 1993c. ^{210}Pb dating of lacustrine sediments from Humber Bay (Core 048, Station 42-D1), Lake Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-TN-93-53, 15p.

Turner, L.J. 1993d. ^{210}Pb dating of lacustrine sediments from Hamilton Harbour (Core 049, Station STP-D1; and Core 050, Station STP-BEN1), Lake Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-TN-93-52, 19p.

Turner, L.J. 1992a. ^{210}Pb dating of lacustrine sediments from Hamilton Harbour Station 33 (Core 031, Box 1; Core 032, Box 2; Core 33, Box 4; and Core 034, Benthos 1), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-92-07, 30p.

Turner, L.J. 1992b. ^{210}Pb dating of lacustrine sediments from

Brewer Lake (Core 035) and Costello Lake (Core 036) in Algonquin Park, Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-92-10, 25p.

Turner, L.J. 1992c. ^{210}Pb dating of lacustrine sediments from Humber Bay (Station H27, Core 041; Station H14a, Core 042; and Station H2a, Core 043), Lake Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-92-18, 21p.

Turner, L.J. 1991a. ^{210}Pb dating of lacustrine sediments from the Saguenay River (Core 011, Station S90-103), Quebec. National Water Research Institute, Burlington, Ontario, Technical Note RAB-91-04, 13p.

Turner, L.J. 1991b. ^{210}Pb dating of lacustrine sediments from Adolphus Reach (Core 012, Station C-2) and the North Channel (Core 013, Station C-4) of Lake Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-91-06, 25p.

Turner, L.J. 1991c. ^{210}Pb dating of sediments from the St. Lawrence River Estuary (Core 014, Station E_{90}-551 and Core 015, Station E_{90}-552), Quebec. National Water Research Institute, Burlington, Ontario, Technical Note RAB-91-11, 20p.

Turner, L.J. 1991d. ^{210}Pb analysis of sediments from the St. Lawrence River Estuary (Core 016, Station LE; Core 017, Station 134A; Core 018, Station 145B; Core 019, Station 168 and Core 020, Station 174), Quebec. National Water Research Institute, Burlington, Ontario, Technical Note RAB-91-13, 13p.

Turner, L.J. 1991e. ^{210}Pb analysis of lacustrine sediments from East Lake (Core 021, Station 158 and Core 022, Station 159), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-91-16, 24p.

Turner, L.J. 1991f. ^{210}Pb analysis of lacustrine sediments from the Bay of Quinte (Core 023, Station 875 and Core 024, Station PM1), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-91-22, 23p.

Turner, L.J. 1991g. ^{210}Pb analysis of lacustrine sediments from the Bay of Quinte (Core 025, Station D and Core 026, Station F), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-91-26, 25p.

Turner, L.J. 1990. Laboratory Determination of ^{210}Pb-^{210}Po using alpha spectrometry, Second Edition. National Water Research Institute, Burlington, Ontario. Technical Note LRB-90-TN-07, 63p.

Turner, L.J. 1990a. ^{210}Pb dating of lacustrine sediments from Hamilton Harbour (Core 001, Station 31A), Ontario. National Water

Research Institute, Burlington, Ontario, Technical Note RAB-90-10, 21p.

Turner, L.J. 1990b. ^{210}Pb dating of sediments from the St. Lawrence River (Core 007, Station E90-540; Core 008, Station E90-541; Core 009, Station E90-550), Quebec. National Water Research Institute, Burlington, Ontario, Technical Note RAB-90-17, 28p.

Turner, L.J. 1990c. ^{210}Pb dating of lacustrine sediments from East Lake (Core 002, Station 155; Core 003, Station 156), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-90-21, 40p.

Turner, L.J. 1990d. ^{210}Pb dating of lacustrine sediments from East Lake (Core 004, Station 157; Core 005, Station 160; and Core 006, Station 161), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-90-22, 54p.

Turner, L.J. 1990e. ^{210}Pb dating of sediments from the St. Lawrence River (Core 010, Station E90-542), Quebec. National Water Research Institute, Burlington, Ontario, Technical Note RAB-90-23, 17p.

Turner, L.J. and L.D. Delorme. 1992. ^{210}Pb dating of lacustrine sediments from Hamilton Harbour Station 26 (Core 027, Box 1; Core 028, Box 2; Core 029, Box 4; and Core 030, Benthos 2), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note RAB-92-06, 38p.

Turner, L.J. and L.D. Delorme. 1990. ^{210}Pb dating of sediments from the St. Lawrence River (core 155, Station E7-510; core 156, Station E7-520; and core 157, Station E7-530), Quebec. National Water Research Institute, Burlington, Ontario, Technical Note LRB-90-TN-04, 32p.

Turner, L.J. and L.D. Delorme. 1989a. ^{210}Pb dating of lacustrine sediments from Lake St. George (core 122), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note LRB-89-13, 26p.

Turner, L.J. and L.D. Delorme. 1989b. ^{210}Pb dating of lacustrine sediments from Round Lake (Core 106), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note LRB-89-15, 24p.

Turner, L.J. and L.D. Delorme. 1989c. ^{210}Pb dating of lacustrine sediments from the Bay of Quinte (core 151), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note LRB-89-28, 16p.

Turner, L.J. and L.D. Delorme. 1989d. ^{210}Pb dating of lacustrine sediments from the Bay of Quinte (cores 149 and 150), Ontario.

National Water Research Institute, Burlington, Ontario, Technical Note LRB-89-29, 25p.

Turner, L.J. and L.D. Delorme. 1989e. ^{210}Pb dating of lacustrine sediments from Hamilton Harbour (cores 152, 153, 154), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note LRB-89-30, 18p.

Turner, L.J. and L.D. Delorme. 1989f. ^{210}Pb dating of lacustrine sediments from Grenadier Pond (Core 145), Ontario. National Water Research Institute, Burlington, Ontario, Technical Note LRB-89-31, 28p.

Turner, L.J. and L.D. Delorme. 1989g. ^{210}Pb dating of lacustrine sediments from Turkey Point Marsh (Core 146), Ontario. National Water Research Institute, Burlington, Ontario Technical Note LRB-89-32, 17p.

Turner, L.J. and L.D. Delorme. 1988a. ^{210}Pb dating of lacustrine sediments from Hamilton Harbour (cores 137, 138, 139, 141, 142, 143). National Water Research Institute, Burlington, Ontario, Technical Note LRB-88-9, 42p.

Turner, L.J. and L.D. Delorme. 1988b. ^{210}Pb dating of lacustrine sediments from Lake St. Clair, (cores 140 and 144). National Water Research Institute, Burlington, Ontario, Technical Note LRB-88-10, 13p.

Appendices

Appendix A: Wet and dry weights for core 091.

091 Core Number Station PILON
2.5736 Specific Gravity g·cm^{-3}
81.0734 Surface area cm^2, 10.16 cm Tube diameter
49.5144 Surface area cm^2, 7.94 cm Cutter diameter
0.3923 Rate of sedimentation cm·yr^{-1}
0 NUMBER OF SAMPLES BELOW THE SURFACE BEFORE THE DIAMETER CHANGES TO CUTTER DIAMETER

Sample Number	Wet** Wt.	Dry** Wt.	Vial Wt.	Spec. Grav.
1	91.926	43.800	24.569	2.53*
2	100.228	50.633	24.299	2.53
3	114.013	57.552	23.743	2.53
4	125.100	60.350	24.545	2.53*
5	140.212	73.629	24.558	2.51
6	139.575	85.691	23.735	2.50
7	131.674	72.986	24.321	2.49
8	112.436	57.433	24.565	2.47*
9	137.804	65.005	24.319	2.49
10	128.557	60.068	24.170	2.51
11	124.279	59.746	24.182	2.53
12	119.210	61.219	23.336	2.54*
13	110.520	60.340	24.558	2.53
14	138.106	69.876	24.171	2.52
15	110.520	57.885	23.732	2.51
16	124.104	71.309	23.723	2.50*
17	117.976	71.245	23.712	2.50
18	115.485	65.936	24.140	2.50
19	141.387	82.950	24.296	2.50
20	119.039	71.827	24.173	2.50*
21	137.037	84.840	24.195	2.54
22	127.006	82.112	24.315	2.57
23	144.092	95.998	24.575	2.61
24	98.425	73.569	24.179	2.64*
25	136.538	96.269	24.293	2.66
26	134.495	97.122	23.722	2.67
27	138.949	101.540	24.321	2.68
28	128.603	93.723	24.280	2.70*
29	136.917	96.851	23.646	2.69
30	147.314	104.653	24.354	2.68
31	118.208	85.234	23.343	2.68
32	111.253	83.228	23.700	2.67*
33	139.417	107.751	24.631	2.66
34	161.599	128.188	24.195	2.66
35	140.896	110.214	24.162	2.65
36	189.112	133.845	24.553	2.64*

**Includes Vial Weight
*Measured specific gravity. Other values calculated by linear regression.

Appendix B: Calculation of porosity and uncompacted depths given sample wet and dry weights, (Delorme, 1991) and specific gravity for core 091. Time in years calculated from CIC1 sedimentation rate data.

Samp Numb	Wet Wt. g	Dry Wt. g	Cumm. Dry Wt g/cm2	Water Cont. cm3	Sed. Vol. cm3	Total Vol. cm3	Comp. Thick cm	Comp. Depth cm	Comp. Mid-pt cm	Sample Poros. %	Uncomp Thick. cm	Uncomp Depth cm	Uncomp Mid-pt cm	Time B.P. Years
1	67.36	19.23	0.39	48.13	7.60	55.72	1.13	1.13	0.56	86.37	1.29	1.29	0.65	1
2	75.93	26.33	0.92	49.60	10.41	60.00	1.21	2.34	1.73	82.66	1.69	2.98	2.14	5
3	90.27	33.81	1.60	56.46	13.37	69.83	1.41	3.75	3.04	80.86	2.05	5.03	4.01	10
4	100.55	35.81	2.33	64.75	14.16	78.91	1.59	5.34	4.54	82.05	2.13	7.16	6.10	15
5	115.65	49.07	3.32	66.58	19.51	86.10	1.74	7.08	6.21	77.34	2.67	9.83	8.50	21
6	115.84	61.96	4.57	53.88	24.77	78.65	1.59	8.67	7.87	68.51	3.28	13.11	11.47	29
7	107.35	48.67	5.55	58.69	19.56	78.25	1.58	10.25	9.46	75.00	2.72	15.83	14.47	36
8	87.87	32.87	6.22	55.00	13.28	68.28	1.38	11.63	10.94	80.55	2.04	17.87	16.85	42
9	113.49	40.69	7.04	72.80	16.32	89.12	1.80	13.43	12.53	81.68	2.36	20.23	19.05	48
10	104.39	35.90	7.76	68.49	14.30	82.79	1.67	15.10	14.26	82.72	2.15	22.38	21.31	54
11	100.10	35.56	8.48	64.53	14.07	78.60	1.59	16.69	15.89	82.10	2.12	24.50	23.44	59
12	95.87	37.88	9.25	57.99	14.89	72.88	1.47	18.16	17.42	79.57	2.22	26.72	25.61	65
13	85.96	35.78	9.97	50.18	14.12	64.30	1.30	19.46	18.81	78.04	2.17	28.89	27.81	70
14	113.94	45.71	10.89	68.23	18.11	86.34	1.74	21.20	20.33	79.03	2.53	31.42	30.16	76
15	86.79	34.15	11.58	52.64	13.59	66.22	1.34	22.54	21.87	79.48	2.09	33.51	32.47	82
16	100.38	47.59	12.54	52.80	19.01	71.80	1.45	23.99	23.26	73.53	2.71	36.22	34.87	88
17	94.26	47.53	13.50	46.73	18.99	65.72	1.33	25.32	24.65	71.10	2.80	39.02	37.62	95
18	91.35	41.80	14.35	49.55	16.70	66.25	1.34	26.65	25.99	74.79	2.49	41.51	40.27	102
19	117.09	58.65	15.53	58.44	23.45	81.88	1.65	28.31	27.48	71.37	3.10	44.61	43.06	109
20	94.87	47.65	16.49	47.21	19.05	66.27	1.34	29.65	28.98	71.25	2.79	47.40	46.01	117
21	112.84	60.65	17.72	52.20	23.91	76.11	1.54	31.18	30.42	68.58	3.22	50.62	49.01	
22	102.69	57.80	18.88	44.89	22.48	67.37	1.36	32.54	31.86	66.64	3.21	53.83	52.23	
23	119.52	71.42	20.33	48.09	27.40	75.49	1.52	34.07	33.31	63.71	3.62	57.45	55.64	
24	74.25	49.39	21.32	24.86	18.69	43.55	0.88	34.95	34.51	57.08	3.55	61.00	59.23	
25	112.25	71.98	22.78	40.27	27.10	67.37	1.36	36.31	35.63	59.77	3.80	64.80	62.90	
26	110.77	73.40	24.26	37.37	27.50	64.87	1.31	37.62	36.96	57.61	3.93	68.73	66.77	
27	114.63	77.22	25.82	37.41	28.79	66.19	1.34	38.96	38.29	56.51	4.05	72.78	70.76	
28	104.32	69.44	27.22	34.88	25.76	60.64	1.22	40.18	39.57	57.52	3.85	76.63	74.71	
29	113.27	73.21	28.70	40.07	27.22	67.28	1.36	41.54	40.86	59.55	3.81	80.44	78.54	
30	122.96	80.30	30.32	42.66	29.92	72.58	1.47	43.01	42.27	58.78	3.99	84.43	82.44	
31	94.87	61.89	31.57	32.97	23.11	56.09	1.13	44.14	43.57	58.79	3.65	88.08	86.26	
32	87.55	59.53	32.78	28.03	22.28	50.31	1.02	45.15	44.65	55.71	3.80	91.88	89.98	
33	114.79	83.12	34.45	31.67	31.20	62.86	1.27	46.42	45.79	50.37	4.51	96.39	94.14	
34	137.40	103.99	36.55	33.41	39.14	72.55	1.47	47.89	47.16	46.05	5.07	101.46	98.93	
35	116.73	86.05	38.29	30.68	32.47	63.16	1.28	49.16	48.53	48.58	4.67	106.13	103.80	
36	164.56	109.29	40.50	55.27	41.36	96.62	1.95	51.12	50.14	57.20	4.61	110.74	108.44	

Appendix C. Specific gravity determination.

The specific gravities ($g \cdot cm^{-3}$) of Core 091 sediments were determined using an automated Accupyc pycnometer (Micromeritics, 1992).

Sample	No. of Tests	Uncompacted Mid Depth	Specific Gravity	Mean
1	5	0.65	2.532 ± 0.003	
4	5	6.10	2.528 ± 0.002	
8	4	16.85	2.475 ± 0.002	
12	5	25.61	2.545 ± 0.003	
16	5	34.87	2.503 ± 0.001	
20	5	46.01	2.501 ± 0.002	
24	5	59.23	2.642 ± 0.001	
28	5	74.71	2.696 ± 0.001	
32	5	89.98	2.672 ± 0.001	
36	5	108.44	2.643 ± 0.002	2.574 ± 0.077

Appendix D. Lead Sedimentation Rate Analysis, CIC1 Model.

$\ln(A - A') = \ln(11.585) - 0.079\,(Z) \quad R = -0.937$

where $(A - A')$ = unsupported ^{210}Pb in $pCi \cdot g^{-1}$,
and Z = uncompacted depth in cm.
based on data from lines 4 to 16

Specific Gravity = 2.574 $g \cdot cm^{-3}$ $P/\omega = 11.575$ $\omega = 0.118$

The initial porosity at the sediment/water interface is 88.29

Atmospheric flux rate at the time of collection 1996.129 is 3.040 $dpm \cdot cm^{-2} \cdot yr^{-1}$ or 1.370 $pCi \cdot cm^{-2} \cdot yr^{-1}$

Supported ^{226}Ra activity = 0.356 $pCi \cdot g^{-1}$ or 0.791 $dpm \cdot g^{-1}$

Sedimentation Rate = 0.392 $cm \cdot yr^{-1}$

Mass Sedimentation Rate = 0.118 $g \cdot cm^{-2} \cdot yr^{-1}$

SUMMARY OF ^{210}Pb ANALYSES

Uncomp Depth cm.	Porosity	Total ^{210}Pb $dpm \cdot g^{-1}$	Total ^{210}Pb $pCi \cdot g^{-1}$	Unsupp. ^{210}Pb $dpm \cdot g^{-1}$	Unsupp. ^{210}Pb $pCi \cdot g^{-1}$	Sed. Rate $cm \cdot yr^{-1}$	Years (*)
6.10	0.8205	10.131	4.564	9.340	4.207	0.3428	1978
14.47	0.7500	6.995	3.151	6.204	2.795	0.3163	1950
16.85	0.8055	7.447	3.355	6.656	2.998	0.3491	1948
19.05	0.8168	8.025	3.615	7.234	3.259	0.3288	1938
21.31	0.8272	7.747	3.490	6.956	3.133	0.3423	1934
23.44	0.8210	6.141	2.766	5.350	2.410	0.3422	1928
25.61	0.7957	5.613	2.529	4.823	2.172	0.3396	1921
27.81	0.7804	4.952	2.231	4.161	1.874	0.3492	1916
30.16	0.7903	3.148	1.418	2.358	1.062	0.3185	1901
32.47	0.7948	2.712	1.222	1.922	0.866	0.3492	1903
34.87	0.7353	1.910	0.860	1.119	0.504	0.3244	1889
40.27	0.7479	1.472	0.663	0.681	0.307	0.3386	1877
46.01	0.7125	1.440	0.648	0.649	0.292		
62.90	0.5977	0.791	0.356	0.000	0.000		
108.44	0.5720	1.283	0.578	0.492	0.222		

(*) Year calculated using the sedimentation rate of the sample

Appendix E. Lead Sedimentation Rate Analysis, CIC2 Model.

$\ln (A - A') = \ln (11.410) - 0.227 (X) \quad R = -0.935$

where $(A - A')$ = unsupported ^{210}Pb in $pCi \cdot g^{-1}$,
and X = cumulative dry weight in $g \cdot cm^{-2}$
based on data from lines 2 to 16

Specific Gravity = 2.574 $g \cdot cm^{-3}$ $P/\omega = 11.410$ $\omega = 0.137$

The initial porosity at the sediment/water interface is 88.29

Atmospheric flux rate at the time of collection 1996.129 is 3.467 $dpm \cdot cm^{-2} \cdot yr^{-1}$ or 1.562 $pCi \cdot cm^{-2} \cdot yr^{-1}$

Supported ^{226}Ra activity = 0.356 $pCi \cdot g^{-1}$ or 0.791 $dpm \cdot g^{-1}$

Mass Sedimentation Rate = 0.137 $g \cdot cm^{-2} \cdot yr^{-1}$

SUMMARY OF ^{210}Pb ANALYSES

MidSam Cum. DryWt. $g \cdot cm^{-2}$	Porosity	Total ^{210}Pb $dpm \cdot g^{-1}$	Total ^{210}Pb $pCi \cdot g^{-1}$	Unsupp. ^{210}Pb $dpm \cdot g^{-1}$	Unsupp. ^{210}Pb $pCi \cdot g^{-1}$	Years (*)
1.96	0.8205	10.131	4.564	9.340	4.207	1982
5.06	0.7500	6.995	3.151	6.204	2.795	1959
5.89	0.8055	7.447	3.355	6.656	2.998	1953
6.63	0.8168	8.025	3.615	7.234	3.259	1948
7.40	0.8272	7.747	3.490	6.956	3.133	1942
8.12	0.8210	6.141	2.766	5.350	2.410	1937
8.86	0.7957	5.613	2.529	4.823	2.172	1931
9.61	0.7804	4.952	2.231	4.161	1.874	1926
10.43	0.7903	3.148	1.418	2.358	1.062	1920
11.24	0.7948	2.712	1.222	1.922	0.866	1914
12.06	0.7353	1.910	0.860	1.119	0.504	1908
13.93	0.7479	1.472	0.663	0.681	0.307	1894
16.01	0.7125	1.440	0.648	0.649	0.292	
22.05	0.5977	0.791	0.356	0.000	0.000	
39.40	0.5720	1.283	0.578	0.492	0.222	

(*) Year calculated using the mass sedimentation rate of the sample

Appendix F. Lead Sedimentation Rate Analysis, CRS Model.

Depth Uncomp Mid-Pt cm	Cum. Dry Wt g/cm2	MidScn Cum. Dry Wt g/cm2	Unsupp. Activity pCi/g	Area pCi/cm2	Cum. Area pCi/cm2	Time B.P.* Years	Cum.Avg Mass SedRate g/cm2/yr	Date	Mass SedRate g/cm2/yr
0.65	0.39	0.19	3.945	0.769	0.769	0.725	0.269	1995	0.269
2.14	0.92	0.65	3.945	1.689	2.458	2.378	0.275	1993	0.278
4.01	1.60	1.26	3.398	2.101	4.559	4.560	0.276	1991	0.277
6.10	2.33	1.96	3.548	2.734	7.293	7.642	0.257	1988	0.229
14.47	5.55	5.06	4.207	10.835	18.128	24.000	0.211	1972	0.189
16.85	6.22	5.89	2.795	2.390	20.518	29.086	0.202	1967	0.162
19.05	7.04	6.63	2.998	2.331	22.849	34.969	0.190	1961	0.127
21.31	7.76	7.40	3.259	2.461	25.310	42.631	0.174	1953	0.100
23.44	8.48	8.12	3.133	1.996	27.305	50.548	0.161	1945	0.091
25.61	9.25	8.86	2.410	1.707	29.012	59.324	0.149	1936	0.085
27.81	9.97	9.61	2.172	1.507	30.520	69.763	0.138	1926	0.071
30.16	10.89	10.43	1.874	1.204	31.724	81.528	0.128	1914	0.070
32.47	11.58	11.24	1.062	0.776	32.499	92.307	0.122	1903	0.075
34.87	12.54	12.06	0.866	0.565	33.064	103.324	0.117	1892	0.075
							0.190	Mean	0.149
							0.056	StdDev.	0.079

*B.P. = 1996
Based on data from lines 1 to 15
Total Area equals 34.445

Atmospheric flux rate at the time of collection 1996.129 is 1.07 $pCi \cdot cm^{-2} yr^{-1}$

Appendix G. Mean date calculated for each core slice.

Sample	Uncompacted Mid Depth in cm	Cum. Dry Wt. g·cm^{-2}	Cum. Dry Wt. Mid Sam	CIC1 Year	CIC2 Year	CRS* Year
1	0.65	0.39	0.19	1994 ± 3	1995 ± 3	1993
2	2.14	0.92	0.65	1991 ± 4	1991 ± 4	1993
3	4.01	1.60	1.26	1986 ± 5	1987 ± 5	1991
4	6.10	2.33	1.96	1981 ± 6	1982 ± 5	1989
5	8.50	3.32	2.82	1974 ± 7	1975 ± 7	1985
6	11.47	4.57	3.95	1967 ± 8	1967 ± 9	1979
7	14.47	5.55	5.06	1959 ± 7	1959 ± 7	1972
8	16.85	6.22	5.89	1953 ± 5	1953 ± 5	1966
9	19.05	7.04	6.63	1948 ± 6	1948 ± 6	1959
10	21.31	7.76	7.40	1942 ± 5	1942 ± 5	1952
11	23.44	8.48	8.12	1936 ± 6	1937 ± 5	1944
12	25.61	9.25	8.86	1931 ± 6	1931 ± 6	1936
13	27.81	9.97	9.61	1925 ± 6	1926 ± 5	1926
14	30.16	10.89	10.43	1919 ± 6	1920 ± 7	1915
15	32.47	11.58	11.24	1913 ± 5	1914 ± 5	1903
16	34.87	12.54	12.06	1907 ± 7	1908 ± 7	1890
17	37.62	13.50	13.02	1900 ± 7	1901 ± 7	
18	40.27	14.35	13.93	1893 ± 6	1894 ± 6	
19	43.06	15.53	14.94	1886 ± 8	1887 ± 9	

* Calculation based on a Multiple Linear Regression with an R^2 of 0.9990 and a Standard Error of 1.0730.

NATIONAL WATER RESEARCH INSTITUTE
P.O. BOX 5050, BURLINGTON, ONTARIO L7R 4A6

Environment Canada Environnement Canada

Canada

INSTITUT NATIONAL DE RECHERCHE SUR LES EAUX
C.P. 5050, BURLINGTON (ONTARIO) L7R 4A6

Think Recycling!

Pensez à recycler !