
GEOCHEMISTRY OF LAURENTIDE GLACIAL SEDIMENT AND IMPLICATIONS FOR CLIMATE CHANGE

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INTRODUCTION

Records of large scale climate change have been studied in relation to glacial advance and retreat patterns in a number of ways. The Laurentide Ice Sheet of the late Wisconsin glaciation is known to have reached as far south as southern Ohio, Indiana, and Illinois at its maximum, and this study continues previous work in southwestern Ohio on the Scioto sublobe of the Lake Erie lobe. The second major advance around 19,900 BP extended the farthest, and then retreated in a series of less well documented, smaller readvances and interstades. The better understood periods include the Bølling-Allerød warming from 13000-11000 BP, the Younger Dryas cooling from 11000-10000 BP and subsequent Holocene warming.

Previous studies have focused on radiocarbon stratigraphy and stable Oxygen isotopes to document patterns of advance and retreat, and to link those patterns to global climate events. The radiocarbon studies have been useful in providing not only patterns of climate change, but an accurate chronology to accompany them. Using two radiocarbon dates for correlation, this study focuses on the geochemistry of two cores from a small peat bog in the Mechanicsburg, Ohio area. Specifically it hopes to show how cation exchange capacity and other analyses might be useful in determining or correlating global climate change events.

GEOLOGIC SETTING

The study area (site 0104) sits within a moraine sequence at the southern margin of the Laurentide Ice Sheet. While the terminal moraine lies approximately 50km south of the site, this area is still rich in glacial deposits due to a resistant bedrock ridge which split the sheet into two sublobes. Site 0104 lies on the western edge of the Scioto sublobe- on the eastern edge of the London moraine, and east of the older Bloomingburg moraine (Figure 1).

The basin itself is a small (50x80x10m) peat bog vegetated with shrubs and grasses, no standing water, and no streams flowing in or out. A man-made drainage gully surrounds

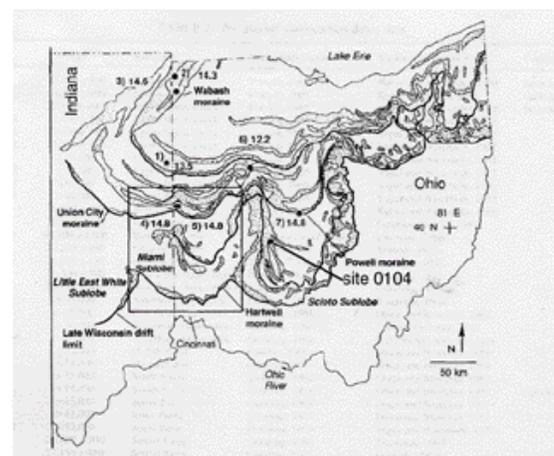


Figure 1. Regional map of the southern margin of the Laurentide Ice sheet. From Lowell, 1995.

the northwest part of the basin, and there are a

few other depressions in the area. The area, like most of Ohio, is underlain by limestone.

METHODS

Field Methods

Samples were collected using a piston corer. Two separate cores were taken one meter apart, each core sampling a different interval starting at 150cm for Core A and 200cm for Core B. All 17 meter-long samples were extracted into PVC tubes with plastic lining, measured, briefly described and photographed. In addition, depth to refusal was probed at 9 other points. Locations for all sample sites and depth points were determined using a Trimble GeoExplorerIII GPS receiver.

Laboratory Methods

Radiocarbon dating, Loss on Ignition

Samples of the core were extracted in the lab and sent to the Limnological Research Center of the University of Minnesota for preparation, and sent to the University of Arizona to be radiocarbon dated using the accelerator mass spectrometer (AMS) method.

1cm³ samples were taken at 4cm intervals from the B core. Each sample was weighed (\pm .005g), placed in a crucible and heated in a furnace for one hour at 500°C to remove organics. Upon removal it was weighed, placed back into the furnace for one hour at 1000°C to remove carbonates, removed and weighed again.

Description, Photos, M.S.

Immediately after sampling, each core was split in half, described in detail, and photographed at close range in small increments. Three magnetic susceptibility measurements were made every 4cm, and the results were averaged for each interval.

Exchangeable Cations

Samples approximately 10g each (dry weight) were taken from the cores at 40cm intervals. Samples were dried for at least 24 hours in an

oven at 40°C before being weighed, and blanks were used for comparison.

Exchangeable Acids

Samples were placed into a flask with 25ml 1N KCl, and set on a slow shaker table for 30 minutes. This solution was vacuum-filtered, rinsing with KCl to bring total volume to 150ml. Total exchangeable acidity was determined by titration with 0.1N NaOH to the first permanent pink endpoint. Exchangeable H⁺ acidity was determined by adding 10ml 1N KF and titrating with 0.1N HCl until colorless.

Exchangeable Bases

Samples were placed into flasks with 40ml of 1N NH₄Cl, and left on a shaker table for one hour. The solution was then vacuum-filtered, rinsing with an additional 60ml of NH₄Cl into a 100ml volumetric flask.

Samples were analyzed for Ca, Mg, Na, and K using a Perkin Elmer Model 3030 Atomic Adsorption Spectrometer. Standards of 1, 2, 5 and 10 mg/L were made up for Na, K and Ca, Mg analysis, with 20ml 5% lanthanum chloride. Dilutions of each solution to .8, .1 and .01 were also made for use in the Ca/Mg analysis, again using 2ml 5% lanthanum chloride. Each sample was then analyzed by either absorption (Ca, Mg) or emission (Na, K).

Grain Size and Clay mineralogy

1cm³ samples were taken from the B core every 4cm, suspended in deionized water, and analyzed with a PC-2000 Spectrex Laser Particle Counter to record mean grain size.

Slides were prepared by separating the <1µm material through use of a sonic dismembrator and centrifuge. This suspension was then vacuum-filtered onto a .45µm filter, and transferred to a glass slide.

Five scans using an X-ray diffractometer were performed. All scans were done from 2° 2θ to 32° 2θ at 1° per minute. Scans were performed after air-drying, an ethylene glycol bath for 24 hours, heating in an oven at 350°, 510°, and after potassium saturation.

Extractable Metals

Nitric acid extraction was used to prepare samples to be analyzed in an ICP-MS. Each sample (approximately 5g dry weight) was dried for 24 hours in a 50°C oven, weighed, and placed in a beaker on a slow shaker table with 50ml 0.1N HNO₃ for 24 hours. Samples were then vacuum filtered and analyzed for Li, Mn, Sr, Mg, Na, Si, Fe, Al, Zn, B, and Ba.

RESULTS

Description, Grain Size, Loss on Ignition, Magnetic Susceptibility, and Clay Mineralogy

A graphical summary of results from these analyses is presented in Figure 2. The X-ray diffraction data shows evidence for the presence of Illite, Chlorite, and Kaolinite.

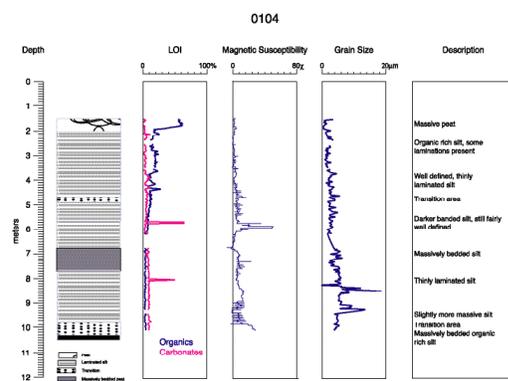


Figure 2. Comparison of Loss on Ignition, Magnetic Susceptibility, Grain Size, and description by depth.

Exchangeable Cations

While the exchangeable acidity was effectively zero, exchangeable bases were more interesting. K and Na did not fluctuate much, Ca and Mg showed definite corresponding peaks. When added together to represent total cation exchange capacity (CEC), the pattern becomes even more clear (see Figure 3). The top of the core shows the highest capacity (just over 30meq/100g). From the high values, it drops gradually until just after the 400cm mark, and then peaks again at 550cm. CEC then drops progressively before steadying out around 15meq/100g for the lower 3m of core.

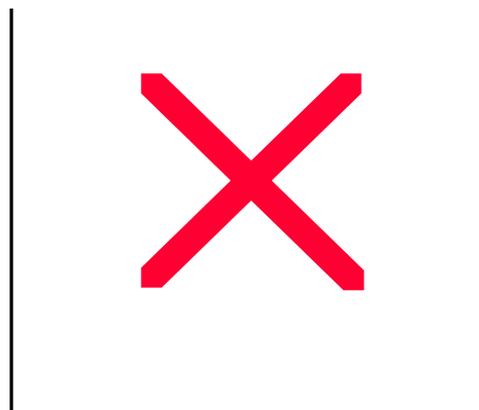


Figure 3. Total Cation Exchange Capacity by depth, including radiocarbon dates.

Radiocarbon dating

Calibration sets for the time period surrounding the first sample are less well developed than others, and so the calibrated ages must be taken with this in mind.

Lab #	Depth (cm)	Years BP	Calibrated Years BP
AA45071	461-462	12,324 ±80	13,087-12,262
AA45072	671-676	15,350 ±100	16,687-16,101

Extractable Metals

DISCUSSION

A few trends become clear by comparing this study with previously dated trends in climate. Based on two radiocarbon dates as benchmarks for timing, most of the data fits patterns which can be correlated with previously identified climate events. Grain size consistently increases with depth, with a few prominent spikes in the bottom two meters. This sediment was most likely deposited near the time of the maximum advance, which could account for its coarser grain size. In addition, the presence of any loess sequences (perhaps the peaks at those depths) would also be represented by areas of coarser grained material.

Magnetic susceptibility and loss on ignition are good illustrators of the younger half of the core. The most noticeable increase in MS occurs at approximately 5.75m. In previous studies, such increases in MS have been linked

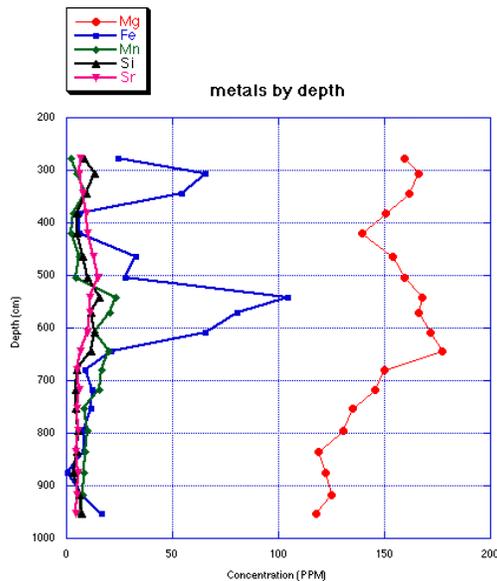


Figure 4. Extractable metals; Mg and Fe roughly follow the pattern seen in cation exchange capacity.

with well developed B soil horizons, and therefore a warmer climate. Based on our dates, this is consistent with a warm period as described by Yu and Wright (2001). Sometime after this (slightly above the first radiocarbon date at 4.6m), the organic content of the section begins to increase, also suggesting a warming of the climate to produce more intra-basin organic material instead of the primary signal coming from clastic extra-basin sediment. This trend continues until the top of the core, where there is a particularly high amount of organic content associated with the peat present there.

Finally, cation exchange capacity supports data from the other methods of analysis. Up until the lower radiocarbon date, total exchange capacity remains relatively low and steady. Shortly after that mark at 15,350 BP, however, there is a dramatic increase in capacity, which can be associated with the general warming and glacial retreat at the time. After peaking at about 5.5m, capacity drops again just after the higher date (12,324 BP), which could represent cooling at the end of the Bølling-Allerød into the Younger Dryas. Subsequent Holocene warming could also account for the following rise in capacity throughout the rest of the core.

CONCLUSION

In conclusion, it is clear that there is a basis for the use of geochemistry as an indicator of global scale climate change when applied to local scale sediment samples. Using cation exchange capacity, loss on ignition and grain size, previously determined climate events associated with the Laurentide Ice Sheet and late Wisconsin glaciation could be potentially identified and correlated with two sediment cores from a small basin. Changes in geochemistry throughout the cores suggest warm and cold intervals that may correspond with the Younger Dryas and the Bølling-Allerød. Although this study is not used for that purpose, this data suggests that geochemistry could be used along with radiocarbon dating to create a much higher resolution record of climate oscillations during the late Pleistocene and early Holocene.

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