Chronology of Lake Productivity at Appleman Lake, IN

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Abstract

Loss on ignition is a widely used method to estimate the organic and carbonate content of lake sediments. Sediments recovered from Appleman Lake showed much stratification in the sediment cores these variations included sand, clay, silt, and rock layers. This observation indicated oscillations in productivity of the lake. Sedimentation in lakes controlled mainly by process related directly to climate (1). Depth at 937.5 cm was radiocarbon dated at 13,550 years before present. The objective in collecting LOI data is to study changes in the environment over time.

Introduction

Twenty thousand years ago the most recent glacial age was at its pinnacle. Though most believe that glacial ages (ice ages) are that they consist of winter year around with continuous blizzards and very low biodiversity, although; glacial conditions were very different from modern times. The contrast between seasons in the climate is what drove ancient ice ages. Winters were what most would imagine them to be, with harsh weather and very little biological activity, they actually included seasons, but the contrast between seasons was minimal. The difference between glacial and modern conditions is that the warm periods were not warm enough to reverse the aftermath of the cold periods.

Glaciers form from thousands of years of snowfall, and are known to be kilometers thick. Glaciers melt because of starvation. Starvation occurs when there is not enough precipitation to feed the ice sheet, and as equilibrium of the season took place and temperatures warmed the ice begin to melt. As the ice sheets began to melt they left a growing expanse of naked ground where, at first nothing lived.

At the end of the last glacial period the climate started to change and glaciers retreated and, the land became more

productive. Areas once covered by ice evolved into thriving biomes(6).

The objective of this project was to reconstruct the paleoenvironment around the Appleman Lake area located in LaGrange County Indiana. Lake sediments were analyzed to gather Loss on ignition (LOI) and charcoal data. These results can give records of local climate and fire events.

Figure 1. Laurentide Ice Sheet covering Northern Indiana at the Pleistocene/Holocene boundary

Methods

In October 2005 lake sediments were taken from Appleman Lake in LaGrange County, Indiana. The sediment cores were then taken to Minnesota to be split, imaged, and scanned for magnetic susceptibility at the National Lacustrine Core Repository at the University of Minnesota's Limnological Research Center. One split was sampled and bagged and the other is an archive.

Loss on Ignition

From research core sediment was taken at every 10cm to be processed for LOI data. LOI gives a record of productivity of the lake. More specifically it gives the percent composition of

water, organic carbon, inorganic carbon, and trale mineral in the lake. A spatula and a syringe were used to gather $2cm^3$ to be inserted into ceramic crucibles. Each crucible was weighted by a microbalance. After being weighed the samples were put into a muffle furnace to be heated, burning off water, organic carbon, and then inorganic carbon. When finished the hot crucibles were placed in a desiccator to ensure no atmospheric moisture is absorbed by the samples. Crucibles were weighed empty, with weight recorded on a spreadsheet before samples were placed in them. Wet weight was then recorded once each crucible is loaded with a subsample. These samples are heated at 100-105˚C overnight in the muffle furnace to remove water. Samples were then taken out and cooled in the desiccator to prevent moisture uptake. The dry weight is then recorded after samples have cooled. A 4 hour burn in the muffle furnace follows, during which organics will be eliminated. (Time starts when temperature reaches 550˚C) After weights are recorded the samples were returned to the furnace for a 2-hour 1000˚C burn. This is to remove carbonate material and some of the water stored in the lattice of clay minerals and diatom silica. After cooling this is the final measurement. Before the next run crucibles are washed with tap water, rinsed with distilled water and air dried over night added to the Petri dish and placed back into the drying oven (without lid) until all liquid has evaporated. Once all the liquid was evaporated, the Petri dish was capped and stored until counting.

Results

Due to time charcoal data will be presented in future studies. Our findings show major oscillations between Organic and Inorganic and Carbonate percentages (5). Organic and inorganic appear to be mirror images of each other up until around the 540 cm mark. Carbonate percentages peak early and then settles to around 5 percent, then show a sudden peak around the 420cm mark. Organics and Carbonate percentages show variations from around 580cm through 780 cm and then a sudden drop off in Organics and peak in inorganic. Organic percentages remain below 10 percent for the remainder of the core inorganic remains between 65 to 80 percent. The date of entire core is unknown but, centimeter 937.5 was radiocarbon dated at 13,550 calendar years ago.

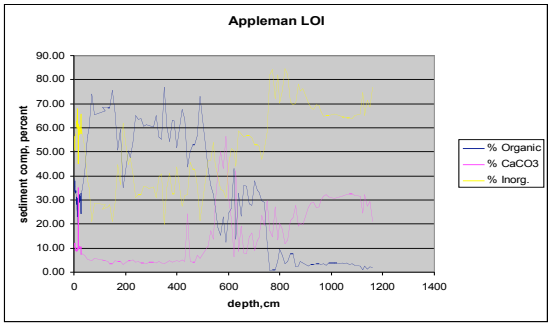

Figure 1.

Unusual variations occur between 600cm and 950 cm to determine if this variation reflects actual periodicity or a systematic error. At these depths the core displayed different stratifications from top to bottom. Samples in that area were retaken at 5 cm intervals

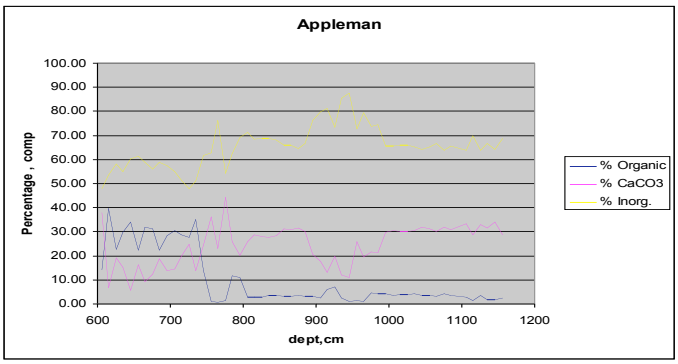

Figure 2.

Figure 3. Results from figure 2 & 3 combined

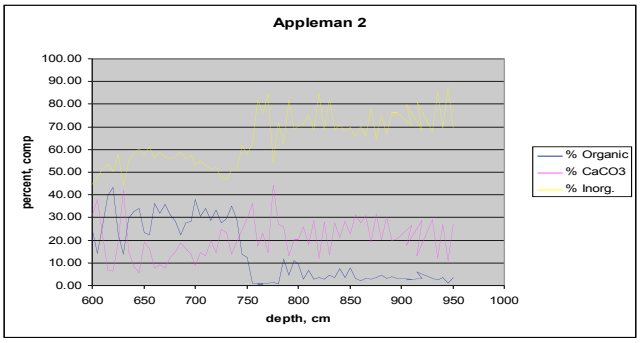

Figure 4.

Discussion

As glaciers maneuver over land it forms trash layers. Trash layers are debris (e.g. rocks, sand) picked up at the bottom of

the glacier. When the piece of ice separated the glacier meltwater contained large amounts of suspended inorganic debris (2). This explains the high percentage of inorganic at the deepest depths (Figure 2). The low organic, moderate carbonate content represents cool periods with sufficient moisture. These conditions results in low lake productivity, increased terriginous input, and decreased vegetal cover (3). About 12,800 years ago the earth experiences a sudden climate change. The earth returned quickly to near glacial conditions. The Younger Dryas was the most significant rapid climate change event that occurred during the last deglaciation. At 780 cm data show signs of warming. Warm conditions increase lake productivity. A decrease in organic productivity indicates cooling and deficient moisture. Around 14,700 year before present (bp) the earth started to warm up after 100,000 years of and ice age. This period is known as the Bölling-Allerød (7).

Today, farms and residential homes are near the lake; runoff from the homes and farm affect the results.

Significance

Appleman Lake contains the history of the lake Quaternary period, further divided into the Pleistocene/Holocene era. These represent the time of the most recent glaciations and deglaciations. During the Pleistocene (11,200 B.P. to 10,000 B.P.) relatively cool and dry conditions persisted. The early Holocene (10,000 B.P. to 8,200 B.P.) is interpreted as warmer with probably more precipitation (4). Over time macrofossils (e.g. pollen, fossils, and shells) settle at the bottom of the lake. The macrofossils are well preserved and can give good insight on the past environment. Lakes are subject and sensitive to local environmental changes; for example aquatic plants thrive in warm periods, therefore, photosynthesis rates are high which deoxygenate the lake and causes life (organics) to decrease and carbonate percentages to increase(3). Appleman Lake represents the local environment, but with analysis it can be compared to other analysis in the region, country, or world to look at local, continental, or global changes. It is vital that we study pass events to know how these changes affect the environment and enable us to prepare for future environmental shifts.

Future Study

Future Study includes charcoal, pollen, and spore analysis for Appleman Lake. Pollen analysis reveals past vegetation in the area. Spore analysis gives an estimate of large plant eating animals present (mega-herbivores). Collections of data from these proxies give images of environments that no longer exist (non analog) and we will be able to study the climate and the effects it had on the vegetation and mega-herbivores. On June 21-23 Spicer Lake was cored it is a site of future study. Spicer Lake is located in northern Indiana in the South Bend area.

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References

1. Davis, M., Ford M. Sediment Focusing in Mirror Lake, New Hampshire. Limnology and Oceanography, Vol. 27, No1. (Jan., 1982), pp. 137-150

2. Karlen, W. Geografiska Annaler. Lacustrine Sediment Studies. A Technique to Obtain a Continous Record of Holocene Glacier Variations. Series A, Physical Geography, Vol. 63, No. ¾. (1981), pp. 273-281

3. McDonough , J. THE MARL LAKE SEDIMENTS OF LAKE BASIN, BELLEFONTAINE, OHIO: A RECORD OF HOLOCENE ENVIRONMENTAL CHANGE.

4. Nesje, A., Dahl, S. O. 2001. The Greenland 8200 cal. Yr BP event detected in loss-on-ignition profiles in Norwegian lacustrine sediment sequences. J. Quaternary Sci., Vol. 16, pp. 155-166. ISSN 0267-8179

5. Oliver Heiri, Andre F. Lotter, & Gerry Lemcke. Loss on ignition as a method for estimating organic and carbonate content in sediments: reproducibility and comparability of results. Journal of Paleolimnology 25: 101-110, 2001.
6. Pielou, E.C. After The Ice Age. The return of life to Glaciated North America. 1991

7. R. B. Alley, J. Marotzke, W.D. Nordhaus, J. T. Overpeck, D. M. Peteet, R. A. Pielke Jr., R. T. Pierrehumbert, P. B. Rhines, T. F. Stocker, L. D. Talley, J. M. Wallace. Abrupt Climate Change. REVIEW