GEOMORPHIC, SEDIMENTOLOGICAL AND CLIMATIC IMPLICATIONS OF INORGANIC HORIZONS IN RITTERBUSH POND, VT

A Progress Report Presented

by

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to

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of

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The following members of the Thesis Committee have read and approved this document before it was circulated to the faculty:

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Date Accepted: ____________________

FOR ALL FIGURES SEE POSTER IN MAP ROOM

Introduction

Lake sediment cores from Ritterbush Pond, located in north-central Vermont (Figures 1 and 2), show variation in sediment type since deglaciation (>12,000 14-C ybp). Distinct gray and brown inorganic horizons, from 1 mm to 10 cm thick, are visually identifiable within a core primarily composed of black organic gyttja (sediment deposited as a result of primary productivity in the lake). Research by members of the UVM Geology Department suggests that the horizons are deposited rapidly, and are composed of terrestrial sediment from the surrounding hillslopes (Bierman et al, 1997). My research investigates these inorganic horizons in order to determine their significance to the sedimentologic and geomorphic history of the Ritterbush Pond watershed and asess implications of these horizons for climate change in Northern Vermont during the Holocene.

The objectives of this research are to determine the spatial and temporal distribution of the inorganic horizons, to describe their physical stratigraphy, and to investigate changes in sedimentation mechanisms in the watershed. This research will 1) refine the chronology of sedimentation events in Ritterbush Pond, 2) estimate rates of inorganic and organic deposition in the pond, 3) determine the importance of fire and storm frequency to depositional events and 4) establish a methodology for future investigations of the inorganic sediment record in ponds.

Work Completed

Coring

In January and March of 1997, we (Sarah Brown, Paul Bierman and members of the Geology Department) retrieved three continuous cores from Ritterbush Pond using a modified Reasoner coring device (Reasoner, 1993). Core 2 is located in the center of the pond; cores 3 and 4 are located toward the lake margin (Figure 2). Core 4 is the only core that bottomed in till; cores 2 and 3 did not reach the bottom of the lake sediment. The 3.5 inch diameter PVC cores were cut into 1 to 2.5m segments to facilitate transport out of the field, and allow for refrigerator storage.

Laboratory Analysis

Magnetic Susceptibility

While the cores were still encased in PVC pipe, down core magnetic susceptibility was measured. The cores were passed through a magnetic coil which determines the bulk susceptibility of the core with respect to a free air measurement. The terrestrially derived inorganic horizons have a higher susceptibility than the lacustrine gyttja due to the presence of magnetite and other magnetic minerals in the sediments of the watershed. Measurements were taken every 3 cm for the length of the core, and each core was measured 3 times. The average values for each core are reported in Figure 3.

X-radiographs

Using an X-ray machine at UVM Radiation Safety, we X-radiographed the unopened cores at 30 cm intervals (kV=63, Mas=16, sec=0.2). The film used is clear, and X-rays pass through less dense material (gyttja), turning the film black, and are absorbed by denser material (inorganic), leaving the film clear. These images were then scanned and NIH image was used to quantify X-ray opacity for each core (Figure 3).

Core Splitting, Logging and Sampling

After magnetic susceptibility and X-ray analysis had been performed, each core section was split lengthwise. One half of each segment was wrapped and sealed in plastic and returned to cold storage as an archive. The remaining half was photographed (35 mm film) and videotaped (Hi 8) at 30 cm intervals under 75 watt daylight bulbs. The cores were graphically logged from the top down, noting color, consistency, grain size, contacts between inorganic and organic material, and the location of macrofossils.

The cores were then systematically sampled into 20 ml glass or plastic bottles and the bottles were returned to the refrigerator. The entire core was sampled at 1 cm intervals. Where changes in lithology were distinct, the sampling interval was altered to capture the contact (commonly 5 mm rather than 1 cm). Macrofossils were removed from the surrounding sediments and stored separately. The cores were also sampled for stable carbon isotope analysis on a millimeter scale in areas where the larger scale sampling was insufficient to reflect distinct stratigraphic features.

Loss-on-Ignition (LOI)

From each sample bottle, an aliquot (<2 g) of sediment was removed for loss-on-ignition analysis. LOI is commonly used as a proxy for organic carbon content. The aliquots were placed in porcelain crucibles, dried overnight, and burned for two hours at 450 °C, measuring the change in weight at each stage. This procedure was modified from Berglund (1986) and has been extensively used by P.T. Davis of Bentley College, MA. Three replicates were run of eight samples with varying LOI values, and crucible weight was routinely monitored to demonstrate reproducibility of the method (Figure 4).

Initial Findings

Stratigraphy

Stratigraphic data delineate the boundaries of 20 to 40 discrete inorganic horizons per core. The inorganic horizons can be divided into two types; thicker (1-10 cm) graded and non-graded beds, and thinner (<1 cm) laminations. Core C2 is characterized by black gyttja in sharp contact with the graded horizons (2-10 cm) of silt and fine sand and thin (<5 mm) silt laminations. Core C3 is comprised of macrofossil-rich (macrophyte and terrestrial plant), silty brown gyttja and graded horizons (2-7 cm) of silt and fine sand bounded by macrofossil and leaf layers. The laminations in C3 are generally thicker (<1 cm) and coarser (very fine sand) than those in C2. Core C4 is characterized by brown gyttja with less organic material than C3. The graded horizons (2-7 cm) in C4 are of silt and fine sand, while the laminations (<1 cm) are of silt. The graded nature and the distinct upper and lower boundaries of the inorganic horizons suggest they were deposited by turbidites.

Lab Analyses

In each core, magnetic susceptibility, X-radiographs, and LOI correspond well with lithologic data. Magnetic susceptibility records only the largest horizons (thick or coarse grained), while LOI and X-ray data show almost all visible layers, and occasionally detect subtle variations in visually homogeneous sections (Figure 5). Magnetic susceptibility values (SI units) are 0 to 2×10^{-5} for the background gyttja, while the inorganic horizons range from 2×10^{-5} to 2×10^{-4}. The inorganic sediments have 5 to 15% LOI and the surrounding gyttja averages 35% LOI. Density of the X-radiographs is measured by grayscale values. The gyttja average value is 150, while the inorganic horizons have values less than 100.

I have not been able to correlate individual layers between cores with any confidence, due the vast differences in type of material within the cores, but in all three cores these thick beds and finer laminations are common in the upper and lower sections of the cores, and absent in the middle of the cores. I have identified three zones of deposition within the lake (Figure 4). Zone 1 corresponds to approximate sediment depth 150 - 250 cm in C2, 70-140 cm in C3, and 50 - 150 cm in C4. Zone 2 is at 420 - 470 cm in C2, 360 - 420 cm in C3, and 280 - 320 cm in C4. Zone 3 corresponds to 500 - 560 cm in C2, 440 - 500 cm in C3, and 340 - 390 cm in C4. In order to confidently match these zones, or individual inorganic horizons, it will be necessary to obtain additional 14-C dates.

Dating of Cores

I have made a tentative match to a well-dated pair of overlapping cores (RT-1, RT-2, total length = 5.75 m) taken in conjunction with pollen research in 1995 (Lin, 1996). The location of RT-2 has been approximated using photographs of the coring expedition, and core C2 (5.6 m) was collected within a few meters of RT-2. Both were taken at a water depth of 13.5 meters at the center of the pond. Three >9 cm horizons are located in both cores, and these horizons are dated in RT-2 at approximately 3000, 6500 and 9000 14-C ybp. Two samples from C2 were dated (depth = 439.7 cm, 6050 ybp, macro; depth = 548 cm, 9070 ybp, gyttja) and confirm the match (Figure 3).

Work Remaining

In progress

Stable Carbon Isotope Analysis

I have chosen to perform cm by cm stable carbon isotope analysis across the largest of the graded horizons. In Ritterbush Pond, the terrestrial and aquatic plants exhibit differences in 13-C and can be used to determine the source of the organic carbon in the lake sediments (Lini, 1997). The transition of the isotopic values from organic to inorganic may be useful in investigating the sediment source for the inorganic horizons.

Charcoal

In order to explore the relationship between fire and the deposition of the inorganic horizons, core C2 will be analyzed at 1 cm intervals with a nitric acid digestion (Winkler, 1985). This method separates the charcoal from the organic fraction and measures relative percent charcoal in the sediment. If charcoal is abundant around the inorganic horizons, the sediment washed into the lake contained burned organic matter, such as would be found after a forest fire in the watershed. This would suggest that forest fire may be a mechanism for increasing hillslope erosion rates. Absence of charcoal around the horizons is inconclusive, as it may not be preserved in the sediment record. If the charcoal analysis reveals increases in charcoal content around the inorganic horizons, I will prepare thin sections to investigate the size and distribution of the charcoal across sections of interest (Clark, 1988). The thin sections will also be used in conjunction with sediment grain size data to investigate the micro-stratigraphy of the thicker horizons.

To be completed

Field Survey

Initial field surveys around Ritterbush Pond have revealed significant sand at the lake margin (Sarah Brown and Andrea Lini). This summer, a storm deposited three distinct deltas in different parts of the pond (Paul Bierman and Paul Zehfuss). In investigating the spatial distribution of the inorganic horizons, it will be useful to understand the modern sedimentation environment, and identify any active or relict features (landslide scarps, alluvial fans) that may contribute terrestrial sediment to the lake.

Grain Size

I plan to analyze the grain size of inorganic horizons using a Coulter Laser Diffraction Unit at Union College, NY. This will provide sedimentological data regarding the graded nature of the thickest horizons. I will also analyze several of the thinner, possibly correlating, horizons in each core to see if grain size within a layer changes with distance from shore.

Carbon/Nitrogen Analysis (C/N)

If the equipment is available I will to run C/N analysis on core C2 to investigate the changing values of carbon and nitrogen in the sediments. This will also serve to check the accuracy of LOI as a proxy for organic carbon content.

Additional AMS dating

In order to confidently match the three cores I have taken from Ritterbush, additional dates are needed around the suggested zones (1-3). It will also be necessary to obtain basal ages for control on sediment accumulation rates. I plan to apply for the following grants to obtain 14-C funds: Sigma Xi (Nov), AAPG (Jan), GSA (Feb), and Howard (Feb).

Estimated Timetable

Fall - Winter 1997

- complete lab work
- field survey
- present initial findings at National GSA meeting in Salt Lake City
- write methods section of thesis

Winter - Spring 1998

- complete coursework (statistics and seminar)
- data analysis
- write introduction, literature review section of thesis
- present findings at VGS spring meeting

Summer - Fall 1998

- complete and defend thesis for October 1998 graduation
- present findings at National GSA meeting in Toronto

References Cited

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