HIGH-FREQUENCY SEDIMENTATION IN GLACIOLACUSTRINE SEDIMENTS FROM THE LAST GLACIAL TRANSITION, CHAMPAIGN COUNTY, OHIO

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INTRODUCTION

High-frequency climate variability is poorly known during the last glacial stage and yet is necessary to understand the mechanisms of climate change. One potential climate proxy contained in glaciolacustrine sediments is rhythmically bedded silt and clay couplets, specifically varves (Ridge & Toll 1999).

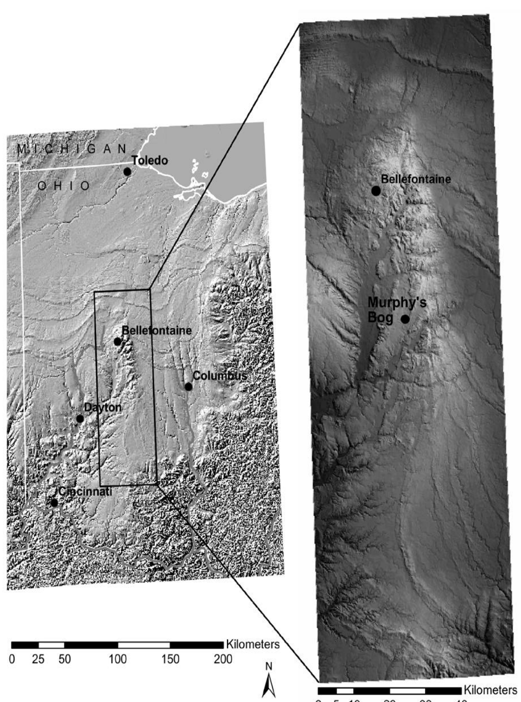

Figure 1. The regional setting of study site in South-central Ohio. Shading represents relief.

Glacial lacustrine varve sequences have yet to be fully employed for study in Ohio and very few records in North America older than 15,000 ^{14}C yr B.P. exist (Ridge & Toll 1999).

Figure 2. Bathymetry of the study site, Murphy's Bog.

The Laurentide Ice Sheet reached its maximum extent in North America 23,000 ^{14}C yr B.P. and at 16,000 ^{14}C yr B.P., upon deglaciation, it created a regional outwash plain among moraines, kames, eskers, and kettle basins in south-central Ohio (Figure 1), which provides a viable background for this study.

Murphy's Bog, one such basin, is located on Silurian bedrock topography covered by glacial till and outwash (Figures 1 and 2). The basin, most likely part of a kame complex, is located on the Ludlow Spur, a remnant of the Scioto Lobe (Pavey et al 1999).

The focus of this research is to describe the glaciolacustrine sediment in the study basin and to determine whether it contains varves. If varves are present in the study basin, the potential to extract paleoclimate records exist.

METHODOLOGY

Murphy's Bog is located near Ludlow and Pisgah Roads in Champaign County, Ohio (UTM Zone 17 4438232N 0271841E) and is situated at 1150 feet above sea level.

A field reconnaissance was made prior to coring to assess the geomorphology of the site. Its bathymetry suggests that Murphy's Bog varies from 6-12 meters deep (Figure 2).

Two sediment cores were extracted using a modified Livingstone Corer and preliminary depth profiles, descriptions, and photographs were made in the field. Approximately 8 meters of sediment core were extracted. Cores 1 and 2 consisted of five thrusts and three thrusts, respectively, reaching depths of 4.5 meters and 2.5 meters below land datum. Each thrust was visually correlated and depths were adjusted on that basis.

Sedimentary features of the cores were examined, described in detail and classed into one of four lithological types using each clay layers as a bound for each sedimentary unit (Table 1).

To augment the lithology analysis, additional lab analyses were conducted, which included magnetic susceptibility, loss-on-ignition (LOI), hydrochloric acid testing, AMS dating, and grain size distribution.

Magnetic susceptibility was measured at 4 cm intervals and at selected 1 cm intervals where significant lithologic changes were noted. Sediment samples were taken at 4 cm intervals for both loss-on-ignition (LOI) and grain size analyses. Hydrochloric acid (HCl) testing for carbonates was done at 4 cm intervals. Macros were sampled from both cores for AMS analysis.

Descriptions of Lithological Types
Type A represents laminations of silt to clay layers, exhibiting both planar and eroded basal contacts.
Type B represents fining upward sequences of coarse grain to fine grain silt and clay, exhibiting both planar and eroded basal contacts.
Type C is massive in appearance and has limited occurrence.
Type D is Holocene organic-rich silt, located at the top of the core and is not considered in this study.

Table 1. Four lithological types found in Murphy's Bog.

Representative types A through D were sampled and quantified using a Spectrex Laser Particle Counter to determine their grain size distribution and then plotted as histograms (Figures 3a and 3b). Optical density analyses were used to help further define the distribution of lithological types (Figure 4).

RESULTS

Major units of the sediment profile of the core can be described from the top as follows: Holocene organic-rich silt transitioning from 259 Pleistocene laminations of sand, silt, and clay. One hundred and fifty-six Type A beds are in the sequence.

Magnetic susceptibility of the core ranged from -0.3 to 80 x 10^-5 SI. An increase occurs at approximately 357 cm below land datum and remains elevated with increasing depth.

The hydrochloric acid reaction testing shows that Holocene sediment is HCl negative and the Pleistocene sediment is HCl positive.

AMS analysis determined ^{14}C ages of 14,986+/-91 for core 1and 16,090+/-100 ^{14}C yr B.P. for core two.

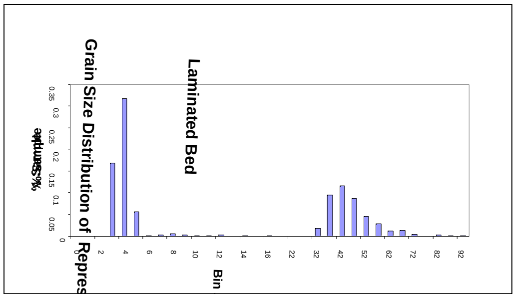

Figure 3a. Grain size distribution of a representative bed. Note the bimodal nature of the laminated bed, suggesting varying energy input. The clay layer (left side of histogram) is thought to represent deposition during the winter quiescent period.

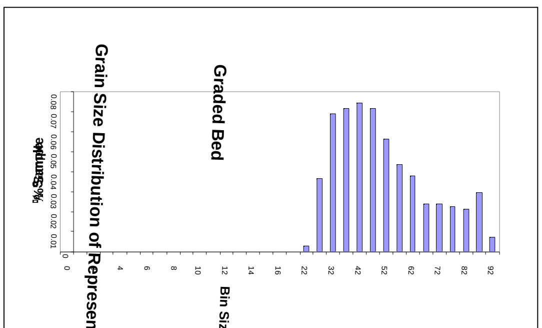

Figure 3b. Grain size distribution of a representative graded bed.

In an effort to begin variability studies to understand the sequencing patterns among the lithology types, the data was synthesized using a transition frequency matrix, which considers the succession of lithological types, developed by Davis (1986) (Table 2).

Bed		A	B	C	D
Laminated	A	55	44	1	0
Graded	B	65	33	2	0
Uniform	C	20	60	20	0
Other	D	0	0	0	100

Table 2. Transition Frequency Matrix of Murphy's Bog, results in percent. For example, reading from left to right indicates that Type B beds follow Type A beds 44% of the time.

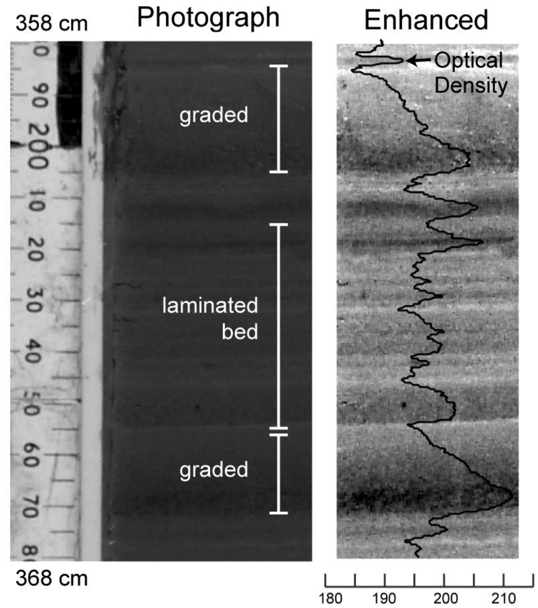

Figure 4. Ten-centimeter interval showing enhanced version of the samples shown in Figures 3a and 3b. The optical density curve supports the bimodal nature of approximately eight laminated units.

DISCUSSION

The basin location, its geomorphology, and its sedimentology suggest that Murphy's Bog was a distal arm of a former ice-contact lake.

The lithology of types A and B, laminated and graded beds, are interpreted as varves and events beds, respectively (Figure 4).

Varves have coarse basal layers, usually consisting of a silt layer capped by a distinct clay layer, forming a couplet with a bimodal grain size, representing an annual deposit. In the core, none of the clay layers fine upward, which is typical of varves (Boyko-Diakonow 1979). In addition, many of the laminated beds seen throughout this core show larger, basal coarse layers capped by a smaller, distinct clay layer, similar to Group III varves as classified by Ashley (1973).

The laminated beds are indicative of varved sediment because of their bimodal grain size distribution (Figure 3a) and thus type A laminations are interpreted as varves.

In contrast, the event beds, containing a fining upward sequence (Figure 3b) most likely resulted from slumping due to slope failure or extreme melting events, represent an instantaneous moment of time.

The transition frequency results (Table 2) indicate a varve stratigraphically succeeds a varve in 55% of the stratigraphy, while in 44% of the stratigraphy an event bed succeeds a varve. If the varve formed annually, this is interpreted as varve production occurring at a frequency of once per year with an event bed occurring at a frequency of once every other year.

An event bed precedes a varve in 65% of the stratigraphy, while in 33% of the stratigraphy an event bed succeeds an event bed. Stated another way, an event directly succeeding another event occurred only once every six years.

CONCLUSION

The stratigraphy of Murphy's Bog consists of type A laminated sediments that occurred at an annual frequency, which are lithologically representative of varves. The sedimentary properties and the bimodal grain size distribution support a seasonal interpretation for the type A laminated beds, interspersed with type B graded beds, which are lithologically representative of event beds, on the average once every other year.

AMS dates, used to constrain a time frame, coupled with 156 type A laminated beds suggest that varve formation began at approximately 16,246 +/-100 ^{14}C yr B.P. and ceased approximately 16,090 +/-100 ^{14}C yr B.P. with glaciolacustrine duration of 156 years. This interval of time is regionally consistent with four AMS dates obtained in various phases of the Keck Glacial Ohio study.

The bedding character of the sediment was influenced by a highly variable forcing mechanism. The next challenge is to define the exact distribution of the type A laminated beds to glean a better perspective on climate variability at 16,090 ^{14}C yr B.P.

ACKNOWLEDGEMENTS

Dr. Thomas V. Lowell, Dr. Warren Huff, Dr. Barry Maynard, Dr. Craig Dietsch, and Dr. David Nash: University of Cincinnati; Women in Science and Research Program; Dr. Greg Wiles, College of Wooster; Dr. Donald Pair and Katie Shoenenberger, University of Dayton; Keck Field Group; W. M. Keck Foundation; Evelyn Mohlaski; and the Geological Society of America, North-central section.

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