BATHYMETRY AND MELT WATER CHARACTERISTICS OF MENDENHALL LAKE- JUNEAU, AK

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INTRODUCTION

Mendenhall Lake, an ice-contact lake at the terminus of the Mendenhall Glacier, is in a valley carved during many advances and retreats. This proglacial lake is continually growing upvalley as the glacier retreats. The purpose of this study is to map the bathymetry of Mendenhall Lake and to determine the physical characteristics of the meltwater passing through.

GEOLOGIC SETTING

Mendenhall Lake is moraine-dammed in a valley carved by the glacier. Kettles adjacent to the lake to the south may have formed at about the same time as the terminal moraine, formed in 1769 (Lawrence, 1950). Other moraines, formed more recently have been dated in the mid 1800s and the early 1900s (Miller, 1975).

The eastern terminus of the Mendenhall Glacier ends in a lake, whereas the western portion rests on a rock arm extension of the valley wall that is being exposed by glacier retreat. An interpretation of the lake floor bathymetry indicates that the morphology of the lake basin is largely controlled by the structure of the underlying rock (Duck, 1985). Bathymetry is also affected by current flow (Benn, 1998) that influences sediment deposition.

METHODS

A Mack-1 bathymeter linked to a GPS (Global Positioning System) receiver mounted in a manually powered inflated boat was used in the study. The GPS was set to record the location of the boat every minute, and at the same time, a tick mark was made on the bathymeter strip chart. Profiles of the lake bottom were recorded in this manner. Depth and location were then compiled as controls from which a map was constructed. An outline of the lakeshore was made using a georeferenced topographic map and aerial photos. Because the only available topographic map shows an out-of-date glacier terminus, GPS data were used to map the current ice front. Using Arc View software, the bathymetric profiles were plotted by downloading the daily traverses, to which depths were assigned in correspondence to the GPS location. The stations plotted show a representative distribution of data. Digital data of depth and location were contoured using a contouring program. Although the resulting map had problem areas, it was accurate for most of the lake basin. Due to the inaccuracy of the computer generated bathymetric map, a hand-contoured version was made. The hand-contoured copy of the bathymetric map, including GPS reference points, was digitized.

A Kemmer water sampler, attached to a calibrated rope, was lowered at various locations to obtain samples from throughout the lake basin and the water column. These samples were used to determine the turbidity throughout various parts of the lake. In many of these same sample stations, a YSI meter was used to measure temperature, salinity and conductivity of the water. The YSI has a margin of error of +/- 0.5% on all readings. One hundred milliliter water samples were hand pumped through filters (45μm) to capture the suspended sediment in each sample. All of the Millipore filters were dried and weighed, and the weight of the suspended sediment was determined in grams per liter. Fifteen of the water samples were brought back to Oneonta, and dried in an oven to check the accuracy of the hand-pumped method. The two methods of turbidity measurements produced similar results. The temperature data collected was averaged by depth throughout the lake, and by east and west basins. This information was compiled into a chart plotting temperature against depth. The salinity in Mendenhall Lake was too low to be detected by the YSI meter used. Conductivity measurements did not vary significantly between stations or at various depths.

DATA ANALYSIS AND DISCUSSION

Upon examination of the bathymetric map (Figure 1), a delta can be seen on the southern shore of the lake. There is also a delta formed by the inflow of water from Nugget Falls on the eastern shore. The eastern basin of Mendenhall Lake has no extensive topographic relief, except at the ice front, where there is a u-shaped depression in direct contact with the ice. It is assumed that bedrock controls this configuration.

Directly south of the rock arm, there is an immediate drop in depth of approximately 100 feet. The bathymetric contours continue to show lower elevations, but over a larger distance to a depth of nearly 195 feet. The southern portion of the western basin has very low bathymetric relief, likely a result of decades of sedimentation. A zone of increased bottom relief found in the western basin corresponds with the moraine complex that exists on the land around the lake. This is likely what remains of the moraines in the lacustrine environment.

The YSI meter used was unable to detect any salinity within the lake. This indicates that the glacier is not excavating marine deposits. Conductivity throughout the lake varied only slightly. The average conductivity measured was 16.9 ms/cm (millisiemens per centimeter), for the lake as a whole. The west basin has an average 17 ms/cm, and the east 17.1 ms/cm, but water near the ice front remained at approximately 16.5 ms/cm (Figures 2, 3). This indicates that the lake is very uniform in electrical conductivity. Ice front measurements may be lower due to the colder water, and because the meltwater has not yet been mixed with water from other sources (such as meteoric, and from other inlets). The water farther from the ice front may also contain an increased amount of dissolved solids.

Temperatures within the western basin were also very uniform. Both the eastern and western lake basins showed no signs of thermal stratification, except possibly at the ice front. Limited ice front temperature measurements showed a decrease in temperature with depth. In the lake as a whole, the lowest recorded temperature was 1.1 degrees Celsius, and the highest was 3.6 degrees Celsius. Throughout the entire Mendenhall Lake basin, the average temperature was 2.3 degrees (Figure 4). These temperature measurements prove the lake is well mixed.

Characteristics of lake sediments are determined by the water source, location within the lake, and the amount of debris introduced into the lake (Syverson, 1998). Most glacial sediment brought into a lake basin remains there with the exception of a small portion of very fine suspended sediment (Ashley, 1995). Turbidity in Mendenhall Lake is low, with very little variation throughout the water column. The maximum amount of sediment found was 0.111 grams per liter, deep in the eastern basin of the lake. At various stations in the western basin, there were suspended sediment weights of less than 0.001 grams per liter (Figures 2, 3). Generally, the grain size of suspended sediment load of an ice-contact lake is finer than fine sand or coarse silt (Benn, 1998). Upon examination of the turbidity table, there is no evidence to even suggest that the lake is sediment stratified (Ashley, 1995).

SUMMARY

Mendenhall Lake is an ice-contact lake that expresses bathymetric features of sedimentation and bedrock control. The meltwater properties are all fairly uniform throughout the lake probably due to wind and currents within the lake. Mendenhall Lake is a feature formed by a retreating alpine glacier; showing similarities to other ice-contact lakes such as the Sheridan Glacier, Alaska. Further study of this lake would allow for sedimentation rates to be determined as well as any annual or seasonal fluctuations in the meltwater properties within.

UNRESOLVED QUESTIONS

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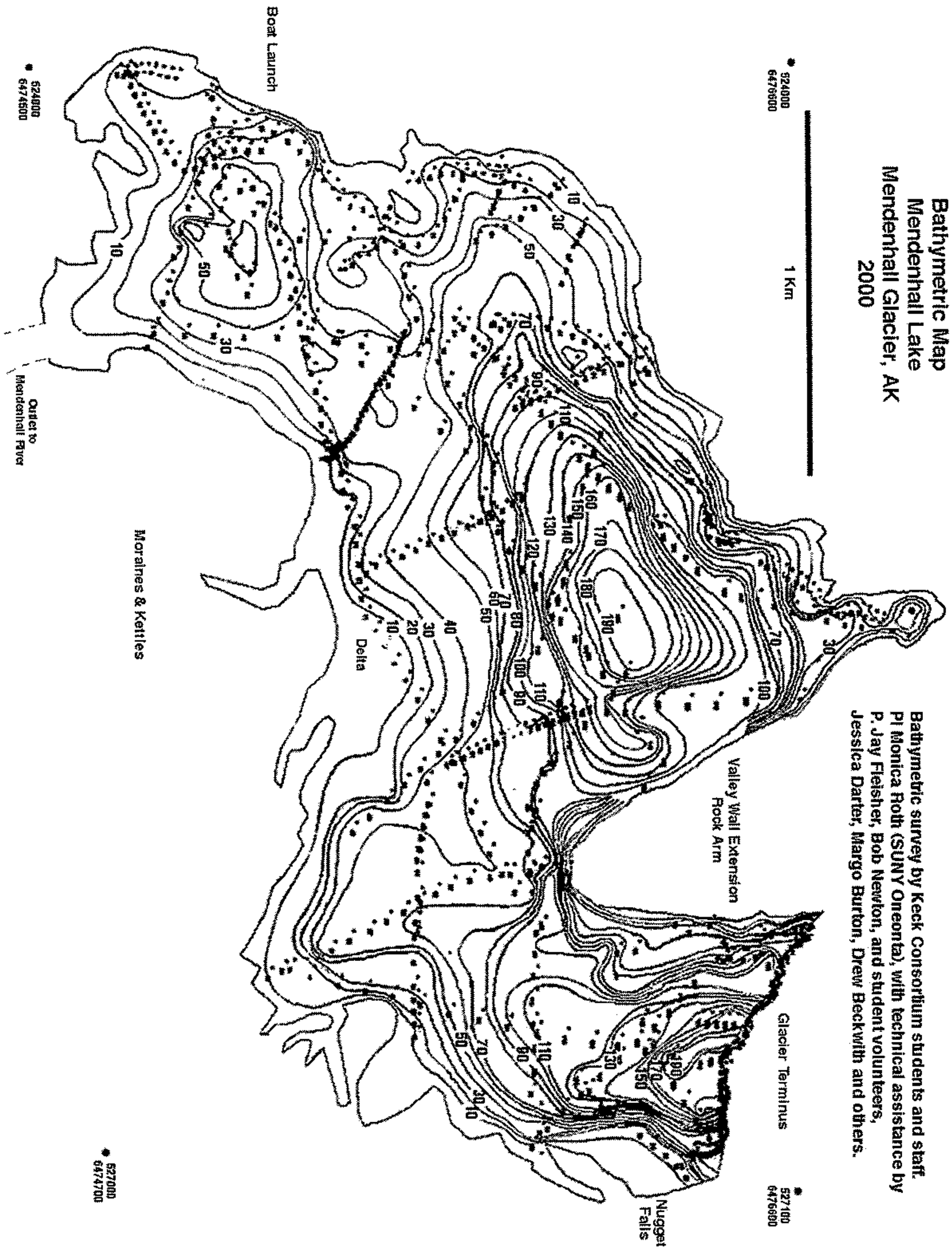
- Why is there such a low suspended sediment load?
- How does this glacial lake compare to others near in the Juneau ice field?
- What are the seasonal and annual fluctuations in water properties?

Mendenhall Lake Bathymetric Map (Figure 1)

Contour Interval – 10 ft



Depth	A	D	N	O	P	Q	R	S	T	U	V	W	X	Y
Surface		0.062	0.056	0.044	0.048	0.038	0.028	0.038	0.054	0	0.041	0.022	0	0.049
3m	0.062		0.044	0.045	0.044		0.03	0.041	0.062	0	0.044	0		
6m			0.051	0.041			0.03	0.049		0.012		0.038		
9m						0.035	0.03	0.043		0.002	0		0.043	
12m														
15m						0.038	0.03	0.043		0.003	0	0.043		
18m													0.039	
21m														
24m						0.044								
27m													0.043	
30m														0.043

Figure 2. Unusually low turbidity measurements within Mendenhall Lake west Basin (in g/l).

Depth	B	C	E	H	I	J	K
Surface	0.079	0.046	0.081	0.035	0.014	0.052	0.068
3m			0.08				
6m			0.084	0.015	0.019	0.062	
9m			0.084				
12m						0.073	
15m			0.024	0.021	0.025		
18m							
21m	0.111		0.06			0.062	
24m				0.014	0.027		
27m							
30m	0.111						
35m				0.039	0.03		
50m					0.047		
60m					0.087		

Figure 3. Unusually low turbidity measurements within Mendenhall Lake east Basin (in g/l)

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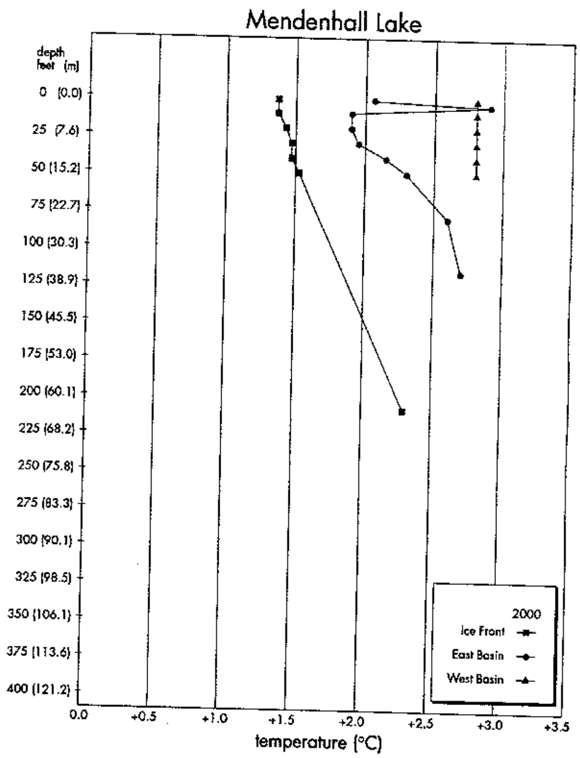

Figure 4. Temperature with depth in the ice front and west basin. The east basin has a peak of high temperature about 3 feet below the surface that may be attributed to the Nugget Falls inlet.

INTERSTADIAL DURATION OF THE HERBERT GLACIER BASED ON SAND ANALYSIS OF A BURIED FOREST SOIL, SOUTHEAST ALASKA

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INTRODUCTION

The Herbert Glacier and its surrounding region provide a useful record of the late Quaternary glacial history of Southeast Alaska. The Little Ice Age, which was an interval of cooler temperatures spanning the 13th to 19th centuries (Lamb, 1977; Calkin and Wiles, 1991), caused the most recent advance of the glacier. This advance and subsequent retreat was studied by Lawrence (1950), who dated the terminal and end moraines in the area by using the theory of ecological succession. The currently receding glacier has recently exposed a buried forest soil that was overridden during the Little Ice Age advance. This soil is best preserved in patchy sections on the stoss side of a roche moutonée to the west of the glacier (fig. 1). The soil is formed on a Pleistocene till, and is composed of a thick peat mat and underlying mineral soil horizons. Both lodgement and ablation till from the latest advance and ensuing retreat overlie the exhumed soil.

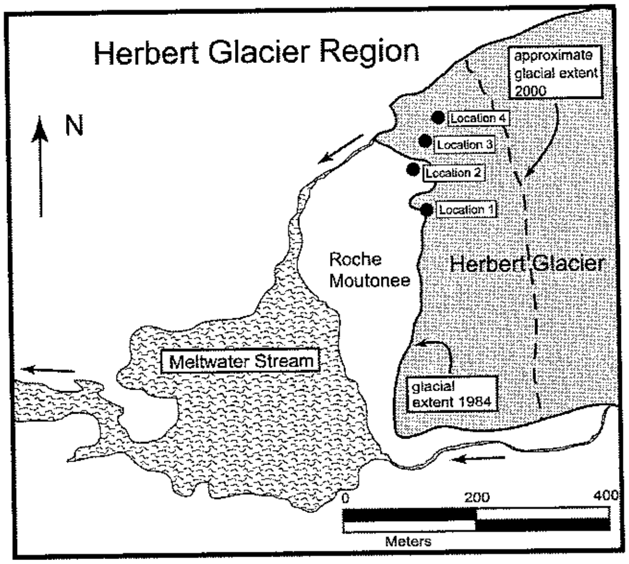

Figure 1. This graphic shows the ice extent and meltwater flow as traced from a 1984 air photo of the Herbert Glacier region. The coordinates of the sample locations were determined with a handheld GPS receiver.

The glacial activity of Herbert Glacier preceding the Little Ice Age advance is relatively unknown, and consequently the buried forest section was studied in order to determine how long this area was exposed to surficial weathering prior to the Little Ice Age advance. Since sparse vegetation appears on till within about three years of deglaciation, the degree of soil development in the region tends to approximate the interstadial duration (Chandler, 1943). From a radiocarbon date taken by Robert Carson (Geochron Laboratories sample no. GX-24424-LS), it is known that the glacier advanced over this forest during the Little Ice Age about 770±40 years ago. Therefore, the duration of the interstadial that separates the penultimate retreat and the last advance of the glacier can be estimated by the degree of soil development within the tonalitic parent material which contains the buried forest section. Soil development is assessed by the etch pit density viewed on feldspar grains from several soil horizons.

METHODS

Samples of the buried forest soil were studied at four different outcrops proximal to the glacier, Location 1 – Location 4 (fig. 1). If there were more than one suitable profile in a specified location, the profiles were further named Location 1a and 1b, for example. Peat was also sampled for radiocarbon dating, as well as wood from an apparently *in situ* tree stump of Sitka spruce that was sheared in the direction of advancing ice flow.

Eighteen soil samples were analyzed in the lab, and with the use of a Gilson sieve shaker, they were each separated into six different sized sand fractions ranging from -1 to 4.5 phi in order to estimate the average grain size of each soil horizon. Selected sieved fractions were cleaned of clays and iron oxides by soneration for 10-30 minutes by the Buehler Ultramet V Sonic Cleaner. The suspended clays were decanted and the remaining grains were washed repeatedly. The samples were then mounted on aluminum stubs with doublestick tape for scanning electron microscope analysis. About 50-100 grains of each sample were randomly mounted, using mainly the 3-4 phi and the 1-2 phi sand fractions. The mounts were then coated with Au-Pd by the Anatech Limited Hummer X sputter coater for three minutes in order to enhance electrical conductivity under the SEM. The JEOL JSM-840A