

Coring for climate: Grain-size analyses of lake sediments, Kigoma Bay, Lake Tanganyika, Tanzania

Student: Nicole Bowerman

Mentor: Curt Stager

Introduction

Grain-size variations in lake sediments reflect changes in the processes and energy of sediment transport. Particle sizes are closely linked to turbulence, wave energy, and proximity to shoreline; increased grain sizes generally correspond to higher energy conditions of sediment production or transport, whereas decreased grain sizes indicate lower energies. Grain-size fluctuations in sediment through time, particularly increases in sand sizes, may reflect low-level lake stands related to periods of dryer and warmer climate. Conversely, decreases in sand content may reflect periods of wet and cold climates (e.g., Alin and Cohen, 2003).

To evaluate these changes during the last thousand years in Lake Tanganyika, I analyzed in detail a series of grab samples along a transect and short and long gravity cores collected from Kigoma Bay, site 1 (Figure 1, Geo Intro). The transect provides calibration points for the long-term climate reconstruction by documenting the changes in grain-size with water depth and distance from shore. I sampled both the short and long gravity cores to construct a continuous record of the late Holocene.

This study provides the first fine-grain size analysis of sediment cores in Lake Tanganyika. Previous studies (e.g., Castaneda et al.; Nyanza Project Annual Report, 1999) have examined grain-size variations in sediment cores through wet sieve analysis, providing a rough assessment of variations in grain size in the lake. The objective of my project is to use a method that provides more precise measurements of grain-size to do a preliminary study of the distribution in grain sizes in lake sediment cores. Because my investigation lacks numerical dates, I compare the sediment trends in the cores to records of previously published late-Holocene lake-level records.

Methods

Grain-size samples, consisting of 0.3-0.5 g of sediment each, were spaced every 2-3 cm in each core to capture general trends in grain size variation. Samples were initially pretreated with 30% H₂O₂ to remove organic sediments. All samples were then pretreated with 1 M NaOH to remove biogenic silica (diatoms). Samples were diluted with distilled water to establish a 1% density of sample volume to diluents volume. When all pretreatment was complete, the samples were analyzed for particle size characterization using a Spectrex Laser Particle Counter PC-2000. This system measures volumetric grain sizes between 1-100 microns by analyzing in-situ the angle of refraction of a laser beam that is aimed through the container holding the sediment/diluents. Several samples contained particles greater than 100 microns (very-fine sand) that settled out of suspension before being measured by the laser; therefore, it was necessary to determine the coarse fraction by wet-sieving in >62 micron mesh size.

Results

LT03K1-17 Grab Samples

Ten grab samples were collected from Kigoma Bay (Figure 1, Geo Intro) in water depths ranging from 20m to 116m on a transect running approximately perpendicular to the coastline. Grain size generally fines with increasing depth, with grain sizes varying from approximately 150 microns (fine sand; proximal) to 31 microns (medium silt; distal) (Figure 1).

LT03-02 Core

Core LT03-02 was collected in 109 m water depth. The core site is on a sublacustrine bench located at the top of a steeply tilted fault block that accumulates mainly fine sediments (Figure 1, Geo Intro). This 92-cm

long (field recovered) gravity core consists of organic coarse silts and fine sands, and several intervals of medium and fine silt (Figure 2). Variations in grain size are significant and abrupt. The bottom of the core is dominated by ~70-100% fine sand for ~15cm before abruptly shifting to 80-95% coarse silt. With the notable exception of one peak in fine sand at 62 cm, the silt remains the dominant particle size between 72-32 cm core depth. The grain-size decreases near the top of this interval with a peak in fine and medium silt between 40-35cm. Between 32-22cm, grain size repeatedly switches between silt-dominant and sand-dominant sediment. The uppermost portion of the core is characterized by ~60-100% silt.

LT03-03 Core

Core LT03-03 was collected in 112 m water depth (Figure 1, Geo Intro). The 57-cm long (field recovered) core consists of organic rich silts and fine sands, with a few peaks in medium silt, but lacks fine silt (Figure 3). The basal sediments (47-37 cm core depth) consist of ~80-90% coarse silt, at the top of which sand peaks to 100% in a thin (< 5 cm) interval before returning to silt-dominated sediment. The overlying 20 cm (37-17 cm core depth) displays a general coarsening-upward trend with an increase of ~10% in sand content. The uppermost third of the core is characterized by abrupt alternating intervals of coarse silt and fine sand. LT03-03 was collected to preserve the sediment water interface because LT03-02 almost certainly is missing it. Therefore, the two cores overlap one another providing a continuous record of late-Holocene sedimentation at the site. If the peak in finer grains at 15 cm in LT03-03 correlates to the peak in finer grains at 3 cm in LT03-02, then LT03-03 preserves an additional 12 cm of latest Holocene sediments beyond that of LT03-02.

Discussion

Variability of clastic sediments in the lake cores suggests that grain-size variation in Lake Tanganyika's sediments is an effective proxy for environmental change in the area. The absence of numerical dates for the cores, however, allows only tentative correlations of the fluctuations to climatic events indicated in other records (e.g., Alin and Cohen, 2003; Cohen et al., 1997). Based on the timing of lake-level increases and declines inferred from ostracodes, Alin and Cohen concluded that Lake Tanganyika was relatively low through the latter part of the Medieval Warm Period (MWP; ~ A.D. 1050-1250), was rising or high during the first half of the Little Ice Age (LIA; ~ A.D. 1250-1550), and was dominated by arid conditions throughout the lake basin during the latter half of the LIA (~ A.D. 1550-1850). Assuming a sedimentation rate consistent with that reported by Alin and Cohen (2003), $\sim 1.2 \pm 0.4 \text{ mm yr}^{-1}$ in the upper meter of their LT-97-56V core, the sediments in core LT03-02 and LT03-03 of this study may represent ~1000 years of sediment accumulation. If this assumption is valid, the fine sand that dominates the lower part (bottom ~15 cm) of core LT03-02 may indicate a period of lower lake levels corresponding to the Medieval Warm Period, and the overlying section of core (~40 cm), which is dominated by coarse silt, may indicate higher lake levels associated with the early Little Ice Age.

Further Research

There is rich potential for further work on the cores collected this year, particularly AMS ^{14}C and ^{210}Pb dating to constrain the abrupt changes in sedimentation recorded in the cores. In addition, finer sampling intervals would improve the temporal resolution available in these cores, as well as confirm the variability apparent in some intervals. Using a laser particle-size analyzer for this preliminary study tested a new approach to grain size characterization for this lake; however, future projects would benefit markedly by using an analyzer capable of measuring a broader range of grain sizes, particularly coarse sediments, so that sieving could be eliminated altogether.

Acknowledgements

I would like to thank "Team Mud's" fearless leader, Curt Stager, for providing his insight and encouragement throughout the course of the projects. Another thanks goes out to Kiram Lezzar and Andy Cohen for their additional geology expertise and I am very grateful to Christine, Shell, and Nate for their amazing ability to 'save the day' on numerous occasions. I would also like to thank the Nyanza Project and all the participants and staff this year for making it such a wonderful and inspiring experience.

References

- Alin, S.R., A.S. Cohen. 2003. Lake level history of Lake Tanganyika, East Africa, for the past 2500 years based on ostracode-inferred water-depth reconstruction. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 1-19. 31-49
- Cohen, A.S., M.R. Talbot, S.M. Awramik, D.L. Dettman, and P. Abell. 1997. Lake level and paleoenvironmental history of Lake Tanganyika, Africa, as inferred from late Holocene and modern stromatolites. *GSA Bulletin*. 109. 444-460
- Castaneda, I., I. Erchak and M. Harper., 1999. Total organic matter, carbonate, and Nutrient distribution in relation to grain-size determination in two east-west coring transects, Luiche and Malagarasi River Deltas, Lake Tanganyika, East African Rift Valley. *The Nyanza Project 1999 Annual Report*. 29-40

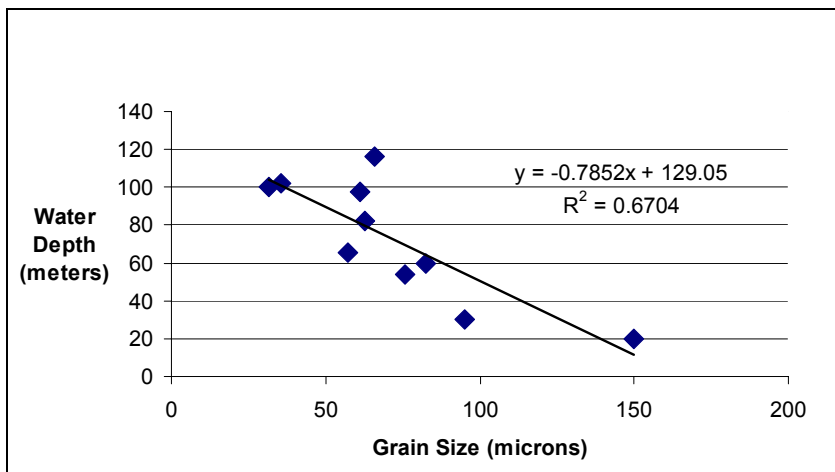


Figure 1. Mean grain-size distribution of grab samples from Kigoma Bay.

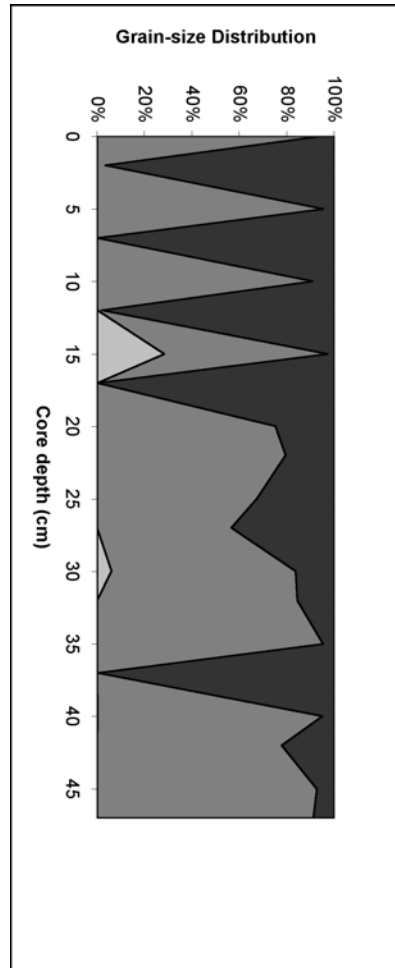
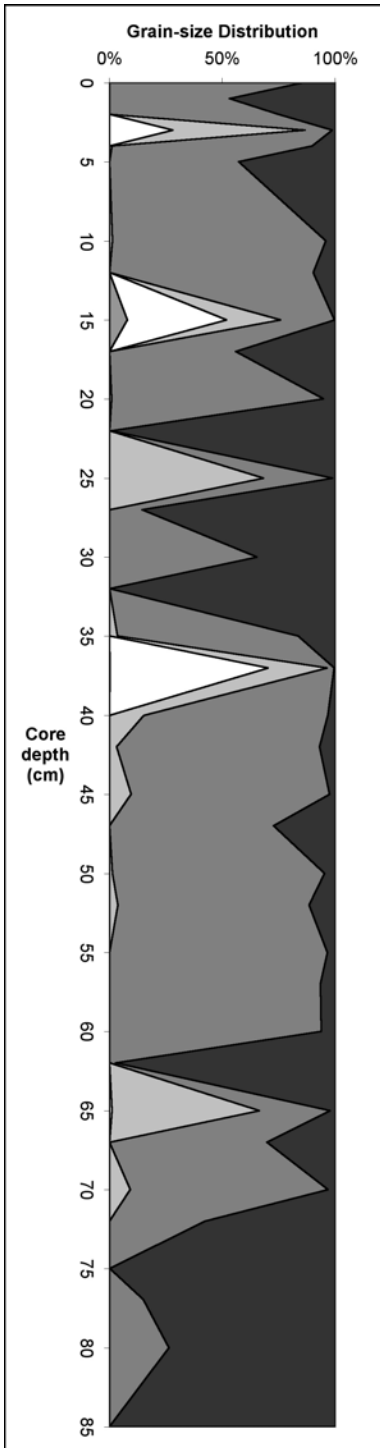


Figure 2: Grain-size distribution in core LT03-02 (85 cm). Ordered left to right: very fine silt, fine silt, medium silt, coarse silt and fine sand.

Figure 3: Grain-size distribution in core LT03-03 (47 cm). Ordered left to right: medium silt, coarse silt and fine sand.