

# When a geology project becomes chemistry: the carbonate vs. diatom content of surface sediments from Lake Tanganyika

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## Objective

The purpose of this study is to investigate the compositional changes in grab samples collected along depth transects in Kigoma Bay and the Luiche Platform. By understanding how diatom and carbonate abundances change with water depth and distance from shore, it is possible to interpret the sediments preserved in the cores. Thus, this study provides a means to extrapolate paleo conditions from the cores.

## Methods

Grab samples LT03-K1 through LT03-K14 were collected during the *M/V Maman Benita* cruise on July 17-18 (see Geo Intro, Fig. 1 for location map). Samples LT03-K15 through LT03-K17 were taken from the *Echo* on a subsequent collection trip on July 20. A GPS was used to determine position and a Raytheon cable-mounted echo sounder was used to measure depth. A ponar grab sampler was used, and the top half-centimeter of each grab was collected in a sample bag. In the lab, each sample bag was thoroughly mixed and a sub-sample was prepared for diatom analysis. Less than one-half milliliter of mud was mixed with hydrogen peroxide to remove organic matter. The samples were then rinsed with water and diluted to make slides. Several of the grabs were from depths less than 5 meters apart, and these samples looked very similar under 400x magnification. Therefore, only one sample from each depth interval was analyzed in detail. From Kigoma Bay, samples LT03-K2, LT03-K3, LT03-K7, LT03-K8, LT03-K15, LT03-K17 were analyzed. Samples LT03-K9, LT03-K10, LT03-K11, LT03-K12, LT03-K13, LT03-K14 were analyzed from the Luiche Platform.

Detailed counts of each slide were made using 1000x magnification and oil-immersion. Diatoms, carbonate crystals, carbonate rosettes (possibly aragonite), phytoliths, sponge spicules, and ostracodes were counted. Diatoms were identified to the genus level, with help from Christine Cocquyt. The counting method used depended on the composition of the slide. For the slides rich in benthic diatoms (LT03-K17 and LT03-K15), 100 total diatoms were counted. Sample LT03-K10 was rich in *Nitzschia*, and so the count was continued until 200 diatoms were recorded. Carbonate dominated the remainder of the samples, and therefore counts continued until 250 carbonate crystals or rosettes were recorded.

## Results

Compositional data for the grab samples are shown in Table 1 and Figure 1. In Kigoma Bay, the shallowest grab sample (LT03-K17 at 20 m) contains 47.1% benthic diatoms, the highest percentage of benthic diatoms observed. LT03-K15 (30 m) is also rich in benthic diatoms and *Nitzschia*. The remaining Kigoma Bay grab samples, which span depths from 59.4 to 116 m, are predominantly carbonate. In the Luiche Platform, LT03-K14 (57.4 m), is mostly carbonate and has only 21.2% diatoms. The next four samples are dominated by carbonate and contain very few diatoms. The deepest sample, LT03-K10 (280 m), has a dramatic decrease in carbonate content and is dominated by *Nitzschia*, which make up 82.4% of the sample.

Figure 2 shows a depth profile of the grab samples. Diatoms are abundant in the shallowest and deepest grab samples but sparse at depths between 60 and 260 m. Benthic diatoms are more common in the shallow samples, whereas the deepest grab sample is mostly *Nitzschia*. Carbonate crystals and rosettes dominate the intermediate depths, making up to 100% of the sample. In all but LT03-K2, carbonate crystals were more abundant than rosettes. In the Kigoma Bay grabs, the two types of carbonates show a similar increase until 82.5 m, where the curves diverge. Carbonate crystal content increases sharply, while carbonate rosette content decreases. In the Luiche Platform grab samples, the carbonate crystal and rosette curves are similar throughout the depth profile, although the crystal values are much higher.

## Discussion

Both Kigoma Bay and the Luiche Platform show similar changes in composition with depth and distance from shore. According to Cocquyt's 1999 analysis of modern diatom assemblages in Lake Tanganyika, the two most important factors governing diatom distribution are distance from shore and depth. In this study, depth was directly measured during sampling using an echo-sounder, while distance from shore was computed by measuring distances on the Geo introduction, Figure 2. For these grab samples, depth and distance from shore are highly correlated ( $r = 0.9647$  for Kigoma Bay,  $r = 0.9981$  for Luiche Platform). Therefore, graphs plotting percent composition versus depth and percent composition versus distance from shore look very similar, and it is difficult to separate the influences of the depth and distance from shore. The shallow, near-shore samples contain many diatoms and few carbonates, while the deeper, off-shore samples are predominantly carbonate. However, diatom abundance increases again in the deepest Luiche sample.

There are several explanations for the abundance of diatoms in the shallow, near-shore samples. Enough light penetrates to the lake floor to support a benthic diatom community. This is not true of deeper waters, implying that any benthic diatoms in the deep-water grab samples were transported from shallower environments. Additionally, near-shore environments generally contain more nutrients, especially silica, because they are closer to terrestrial input. Therefore, higher concentrations of both benthic diatoms and planktonic *Nitzschia* are expected in shallow, near-shore samples, a pattern observed in the grab samples. However, near-shore nutrient abundance does not explain the richness of *Nitzschia* in LT03-K10, the 280 m Luiche sample.

There are two possible reasons for a higher percentage of carbonates than diatoms. First, carbonate precipitation can cause an increase in sedimentation rate. In this scenario, if the absolute number of diatoms that reach the lake bottom in a given time period remains constant, the presence of carbonate causes the relative abundance of diatoms to decrease, thereby diluting them. This raises the question of why very few carbonates precipitate in the shallow environments. Carbonate precipitation occurs according to the equation  $\text{Ca}^{2+} + 2 \text{HCO}_3^- = \text{CaCO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}$  (Wetzel, 2001), and the rate of this reaction increases with increasing temperature. Because shallow water has a higher temperature than deep water, one would expect more carbonate to precipitate, the opposite of the observed pattern. Alternatively,  $\text{Ca}^{2+}$  abundance can control carbonate precipitation. If the dominant source of  $\text{Ca}^{2+}$  is the hypolimnion, then carbonate will be more abundant in the deeper grab samples. This is consistent with all of the samples but LT03-K10, which contains very few carbonates.

Carbonate can also be deposited due to high algal productivity. Under these conditions, though, high proportions of carbonates and diatoms would be expected. Therefore, it is possible that the diatoms are dissolving, which would result in a higher percentage of carbonates than diatoms. Silica is more soluble in alkaline water, and strong bases are often used to dissolve diatoms in grain-size analyses. The diatoms may dissolve in the water column, in which case there will be fewer diatoms in deeper grab samples. Alternatively, the diatoms may be dissolving when they reach the lake floor and are deposited in the presence of carbonate. In order to test this hypothesis, a mini-experiment in diatom taphonomy was performed. Blobs of *Nitzschia* diatomite were removed from core LT03-07. One blob of *Nitzschia* was placed in a test tube with carbonate-rich mud from grab sample LT03-K3 and another blob was placed in a tube of water. These tubes were then warmed in a hot water bath for 5 days in order to speed reaction times. No dissolution was observed, but the time period may have been too short for the reaction to be visible.

## Conclusion

This study measures the relative abundances of carbonate and diatoms in grab samples. Each grab sample is dominated by either carbonate or diatoms, but not both. It is difficult to understand why one sample is rich in carbonate and another is diatomaceous, because different factors influence carbonate precipitation and diatom production. Thus, curves for at least two processes are producing the final composition of the samples. Shallow, near-shore environments contain more diatoms and fewer carbonates, whereas deeper environments are generally dominated by carbonate.

## Future Research

This was a preliminary study of the carbonate and diatom distributions in Kigoma Bay and the Luiche Platform. A number of possibilities exist for further research.

- 1) This project could be extended next year, with geology and limnology students working together to understand how the composition of the lake floor changes with depth and distance from shore. The goal of this project would be to work out the causes and distribution of carbonate deposition at different locations and depths. This study will clarify the usefulness of both carbonate and diatoms as paleoenvironmental indicators.
- 2) Further studies in diatom taphonomy are necessary to learn about the distribution of diatoms in the grab samples. It would be interesting to learn what factors influence diatom frustule dissolution in Lake Tanganyika. Does the presence of carbonate cause greater diatom dissolution? This study has important paleoclimate implications because diatom dissolution influences the use of these organisms as paleoclimate proxies.
- 3) The distribution of the carbonate crystals and rosettes can be analyzed in greater detail. The two particles can be studied using x-ray diffraction to determine their chemical structure. This may also provide information about why ratio of crystals to rosettes varies between the samples.

## Addendum

After completing the grab sample analysis, one week of project time remained. Therefore, I looked for *Aulocoseira* zones in cores LT03-07 (Luiche Platform, 129 m) and LT03-08 (Luiche Platform, 336 m). Core LT03-07 has a small *Aulocoseira* zone at 75.5 cm and a large *Aulocoseira* zone from 129 to 157 cm. Core LT03-08 has small *Aulocoseira* zones at 61 to 64 cm and 120.5 cm as well as a large zone from 132.5 to the end of the core. For further information on *Aulocoseira*, see Meeker, this volume.

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## Bibliography

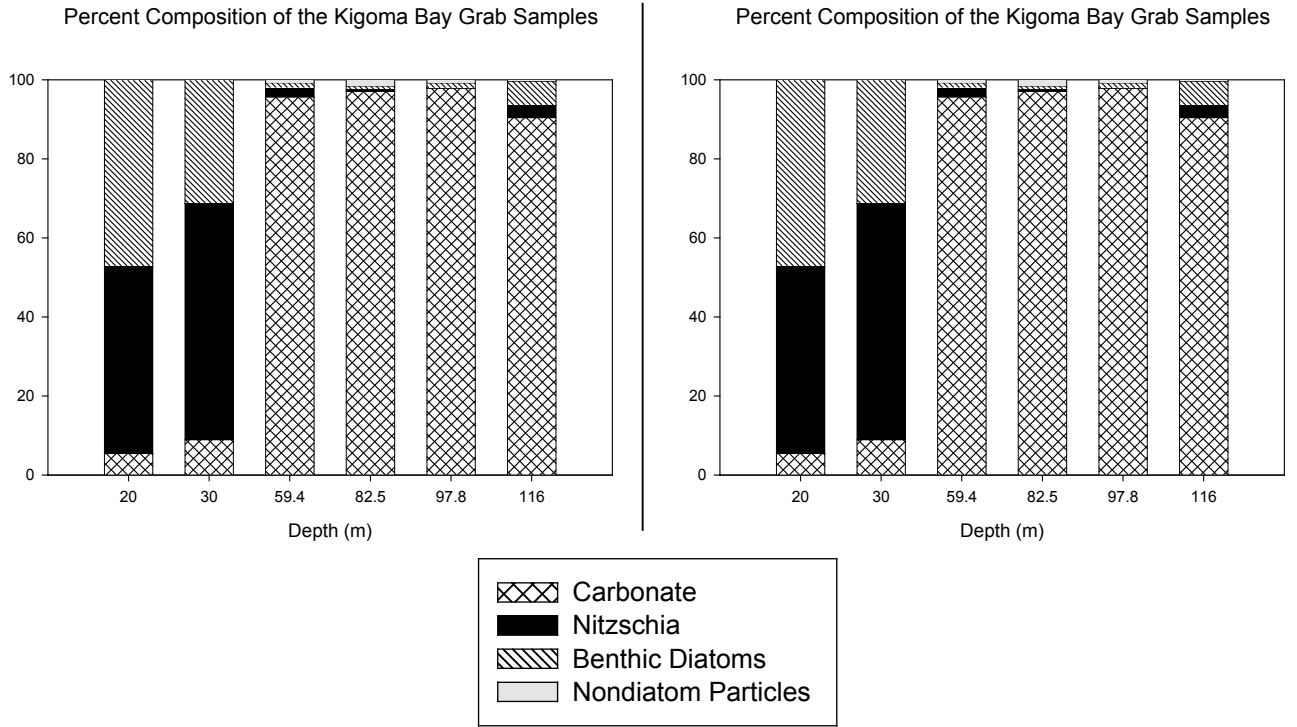
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**Table 1:** Compositional data of the Kigoma Bay and Luiche Platform grab samples

Sample	Site	Depth (m)	% Carbonate Crystals	% Carbonate Rosettes	% Nitzschia	Benthic diatoms	Non-diatom particles
LT03-K17	Kigoma Bay	20	3.6	1.8	47.5	47.1% <i>Navicula, Amphora, Surirella, Fragillaria, Cymbella, Diploneis, Achnanthes</i>	0%
LT03-K15	Kigoma Bay	30	6.2	2.7	59.8	31.3% <i>Navicula, Amphora, Fragillaria, Cymbella, Cocconeis</i>	0%
LT03-K8	Kigoma Bay	59.4	51.6	43.9	2.5	1.2% <i>Navicula, Amphora</i>	0.8% Phytolith
LT03-K2	Kigoma Bay	82.5	47.4	49.7	0.6	0.8% <i>Navicula, Cocconeis</i>	1.5% Sponge spicule, ostracode, phytolith
LT03-K3	Kigoma Bay	97.8	60.6	37.2	0.2	1.2% <i>Amphora, Surirella</i>	0.8% Sponge spicule, phytolith
LT03-K7	Kigoma Bay	116	76.3	14.1	3.3	6.0% <i>Navicula, Amphora, Surirella, Fragillaria, Cymbella, Diploneis, Cocconeis</i>	0.3% Sponge spicule
LT03-K14	Luiche Platform	57.4	69.5	8.6	12.2	9.0% <i>Navicula, Amphora, Fragillaria, Cymbella, Diploneis,</i>	0.7% Sponge spicule
LT03-K13	Luiche Platform	72.4	77.6	21.2	0.8	0.4% <i>Fragillaria</i>	0%
LT03-K12	Luiche Platform	88	71.6	27.9	0	0%	0.4% Phytolith
LT03-K11	Luiche Platform	108	72.8	27.2	0	0%	0%
LT03-K9	Luiche Platform	256	62.8	34.1	1.5	0.8% <i>Navicula, Diploneis</i>	0.8% Sponge spicule, phytolith
LT03-K10	Luiche Platform	280	9.2	2.7	82.4	5.3% <i>Navicula, Amphora, Fragillaria, Cymbella</i>	0.4% Phytolith

**Figure 1:**



**Figure 2:**

