

Diatoms and climate change – The use of diatom analysis in reconstructing Late Holocene climate for Kigoma Region, Tanzania

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Introduction

Diatoms are an effective proxy for climate change due to their sensitivity to a variety of ecological conditions. Past changes in climate can be inferred from changes in species abundance within a sediment core, as the ecological requirements are well known for a number of ‘indicator’ species. These species are indicative of several variables, including lake level and nutrient availability. These variables are dependent upon a combination of primary factors (including precipitation, solar output, and wind strength) and secondary factors (including upwelling and erosion).

Assuming a constant sedimentation rate at the coring site, core depth is analogous to time before present. As diatoms bloom and die, their skeletons settle to the bottom of the lake and are incorporated into the sediments. Diatom valves, or skeletons, are made up of silica, which preserves well over time given little disturbance. This allows for the reconstruction of past climate by analyzing the changes in the preserved diatom valves through time. Diatoms are quite detailed in structure and can be identified to genus and, in most cases, species level. The following results are a preliminary analysis of core LT03-02, located in Kigoma Bay at 109 meters depth, in order to establish climate change for the late Holocene. There are currently no absolute dates for this core, but comparisons to previous records from the region help to extrapolate the possible timing of fluctuations in indicator species.

Methodology

Core LT03-02 was collected at 109 meters depth from a platform on the gently sloping side of a submerged tilted block. This site was chosen due to its isolation from sediment influx from the surrounding basin, as the platform is raised relative to the surrounding lake bottom topography. This increases confidence that sedimentation has been uniform and is not disturbed by major slumps. Once collected, the core was sampled for diatoms at 5cm intervals initially, though later was sampled at 1, 2, and 3 cm intervals to highlight transition zones that were noted. Diatoms were mounted on slides and a total of at least 200 valves were counted. Due to the almost complete dominance of one type of diatom (*Nitzschia* spp.) at several intervals, counts were modified to 100 total valves counted in order to expedite the process and allow more core samples to be analyzed. Scans were done of these slides to ensure that there were no other diatom types being overlooked. Diatoms were identified to genus level using a taxonomic key (Cuquoyt, 1990), and then grouped into indicator-types. Indicator type was determined by reference to previous studies as well as personal communication with on-site diatom specialists Curt Stager and Christine Cucquoyt.

A stratigraphic shift in the upper part of the core to a dominance of carbonates was coupled with a lack of diatom preservation. More information on carbonate fluctuations in this core can be found in Ellen Currano and James Apolkarpi’s research in this volume. In order to look at carbonates in the upper core more closely, I attempted a self-designed method for analyzing carbonate abundance. I counted carbonates using the same slides prepared for diatoms. Carbonate rosettes were observed in 20 fields of view and then compared as a percentage to total diatoms. Because the concentration of material (both diatom and carbonate) is variable in the preparation method, I consider the results to be qualitative at best, and any information on carbonates in LT03-02 should be deferred to other research in this issue.

Results

Five distinct shifts in diatom assemblages were observed in this core (Figure 1). They are labeled Zones 1 through 5, and they are designated by a shift in the dominance of a particular indicator, which includes diatoms and carbonates. They are as follows, beginning with the zone furthest back in time:

Zone 5: Cyclostephanos Dominance (77-86cm)

This zone is defined by a clear dominance of the genus *Cyclostephanos*, which terminates abruptly and is completely eliminated from the record by 77cm depth. The core itself is only 86cm in length, and it is unknown how long *Cyclostephanos* dominated the record previous to the time represented by the base of core LT03-02. There is a slight decrease in the *Cyclostephanos* percentages from 85cm to the bottom of the core at 87cm, but the interval is too small to make any speculations as to whether the decrease is a trend or noise in the record. A deeper core would be required to establish the full extent of this zone.

Zone 4: Nitzschia Dominance (60-77cm)

The genus *Nitzschia* is generally characterized by a long, thin skeletal structure that is favored in many environmental conditions and habitats within Lake Tanganyika. They are abundant in Lake Tanganyika at present, and are seen throughout the entire record to some extent. Zone 4 is a *Nitzschia* dominated zone, increasing to nearly 100% of the total assemblage until its domination terminates abruptly at 60cm.

Zone 3: Aulacoseira Dominance (45-60 cm)

Aulacoseira enters the record as abruptly as the assemblage shifts before it. The period of dominance is short-lived relative to the extent of *Nitzschia* dominance before and after this zone (see zone 2 description). *Nitzschia* is still a noticeable presence throughout this zone, with benthic types (see discussion for definition of indicator diatom types) remaining low as they do for the entire record.

Zone 2: Nitzschia Dominance (30-45 cm)

The genus *Nitzschia* dominates throughout this zone, with no significant fluctuations.

Zone 1: Carbonate Dominance (0 to 30 cm)

This zone is defined by high amounts of carbonate and very few diatoms. It is important to note that diatom density on the prepared slides for this zone was significantly lower relative to all other zones. This may be an artifact of preparation methods, but there is a possibility that the presence of carbonates is associated with low diatom numbers. This could be a result of the dilution of diatoms from an increase in sedimentation during times of high carbonate precipitation, or the environmental conditions favoring carbonate precipitation may advance the deterioration of diatom valves. For more on this issue, see Ellen Currano's section in this report. Diatom percentages, as well as total density, increase with depth, with a termination of the zone at 30 cm when carbonates become proportionally insignificant. Both *Nitzschia* (planktonic) and benthic species increase with the decline of carbonates.

Discussion

The dynamic nature of the diatom record in Lake Tanganyika is apparent. Shifts in diatom assemblages are abrupt, which implies that changes in the environmental conditions in or around the lake were abrupt as well. Lake Tanganyika therefore, is likely sensitive to late Holocene climate events such as the Little Ice Age and the Medieval Warm Period. Radiocarbon dates would allow for the correlation of known climate changes and shifts in the diatom assemblage record.

Even without absolute dates, the diatom genera that are identified in this study can be used to indicate certain environmental conditions. The five zones exhibited in the LT03-02 core are indicative of environmental changes in the following manner:

Zone 5: The genus *Cyclostephanos* consists of large centric (round) diatoms that live in open water (planktonic). They require large amounts of silica in order to build up their large skeletal structure. In order to support a large dominance of this genus, high amounts of silica had to have been transported into the lake, either through upwelling of nutrients from deeper waters or through increased runoff from the surrounding basin. An increase in precipitation would promote such conditions, indicating that this period could have been a time of higher lake levels.

Zone 4: *Nitzschia* species are long thin, planktonic diatoms. They float easily and require little silica, which is likely the reason they persist through the entire record. They currently dominate the modern assemblage, and so I am making the assumption that previous periods of *Nitzschia* dominance are much like the present. Zone 4 is therefore analogous to present climate and lake level conditions.

Zone 3: *Aulacoseira* species are planktonic and have similar requirements as *Cyclostephanos*. They require a high amount of wave action to keep them in the photic zone. Without waves, the heavy valves sink below the layer of water that is penetrated by sunlight and die. An abundance of *Aulacoseira* can therefore be interpreted as a time of increased windiness or storminess. This genus also requires a higher amount of silica, as the valves are large and robust, but do not require as much as *Cyclostephanos*. For this reason, it is possible that increased precipitation, through increased storminess, brought silica into the lake by way of runoff from the basin, but not in enough quantities to support *Cyclostephanos* over *Aulacoseira*. Lake levels would have been higher due to the increase in precipitation.

Zone 2: This zone is *Nitzschia* dominated, and therefore probably analogous to present conditions. It is important to note though, that benthic diatoms increase slightly during this period. Benthic diatoms consist of several genera that live at the lake bottom rather than float freely in the water. They must reside in the littoral regions of the lake in order to receive sunlight, and so are not found in modern samples from deep water. An increase in benthic diatoms within the core suggests the possibility of a lowering of lake level. As lake level decreases, the littoral zone in which these benthics live would shift and bring the zone closer to the core site. Climatically, this would represent a warmer and/or drier period, with increased evaporation or decreased precipitation. Though, the increase of benthics in this zone is slight, and so is not a conclusive indicator of lower lake levels for this period.

Zone 1: Diatoms are unable to provide any information in this zone due to the lack of diatoms and dominance of carbonates. The precipitation of carbonates could increase in the lake system for several reasons, including lower lake levels or an increase in average water temperatures. Catherine O'Reilly (2003) concluded that Lake Tanganyika productivity has been changing in recent history as a result of global warming. It is possible that the formation of carbonates in the lake is also associated with global warming, but that is not conclusive at this point. The carbonate zone in this core is approximately 30 cm in length, which may or may not be the result of only one century of sedimentation. If this zone is indeed a result of global warming issues, then sedimentation rates have increased tremendously relative to other zones.

Other studies provide some information as to the possible time span that core LT03-02 encompasses. Cohen (in press) concluded that sedimentation rates in Lake Tanganyika are approximately 1mm per year. This would mean that core LT03-02 spans about 860 years. The core itself does not represent the top 12 cm of lake sediment, due to the overpenetration of the corer during extrusion. Accounting for the missing 12 cm, the base of core LT03-02 is dated to approximately 980 years. If this is true, then events such as the Little Ice Age and the Medieval Warm Period would be within the span of this particular record, and is represented by changes in the diatom assemblage. Yet, there is controversy about this due to the presence of the *Cyclostephanos* genus at the base of the core. Haberyan & Hecky (1987) conducted a late Pleistocene/Holocene study of Lake Tanganyika using several proxies including diatoms. Their results show that *Cyclostephanos* disappears from the record at approximately 4ky BP, a date constrained by conventional radiocarbon dating. The presence of this genus at the base of core LT03-02 suggests that this core may extend the last 4000 years. This would mean that the sedimentation rates at the LT03-02 site are half that of other sites previously studied in the lake. The possibility of the bottom sediments being turbidites is unlikely, as the sediment is horizontally laminated and does not appear mixed. Due to the low resolution of past diatom studies, this peak of *Cyclostephanos* may also be an event unseen in other records that may have taken place within the late Holocene. Radiocarbon dates for LT03-02 are needed to elucidate this issue.

Further Research

The results from this study show that diatoms are an effective proxy for climate change in Lake Tanganyika, as can be seen from the apparent changes in species abundances throughout the core. There is much potential for further work on this core, including acquiring absolute dates and sampling at higher intervals. The presence of *Cyclostephanos* at the bottom of the core presents the potential for a new addition to the climate story in this area, if indeed the peak took place later than 4ky BP.

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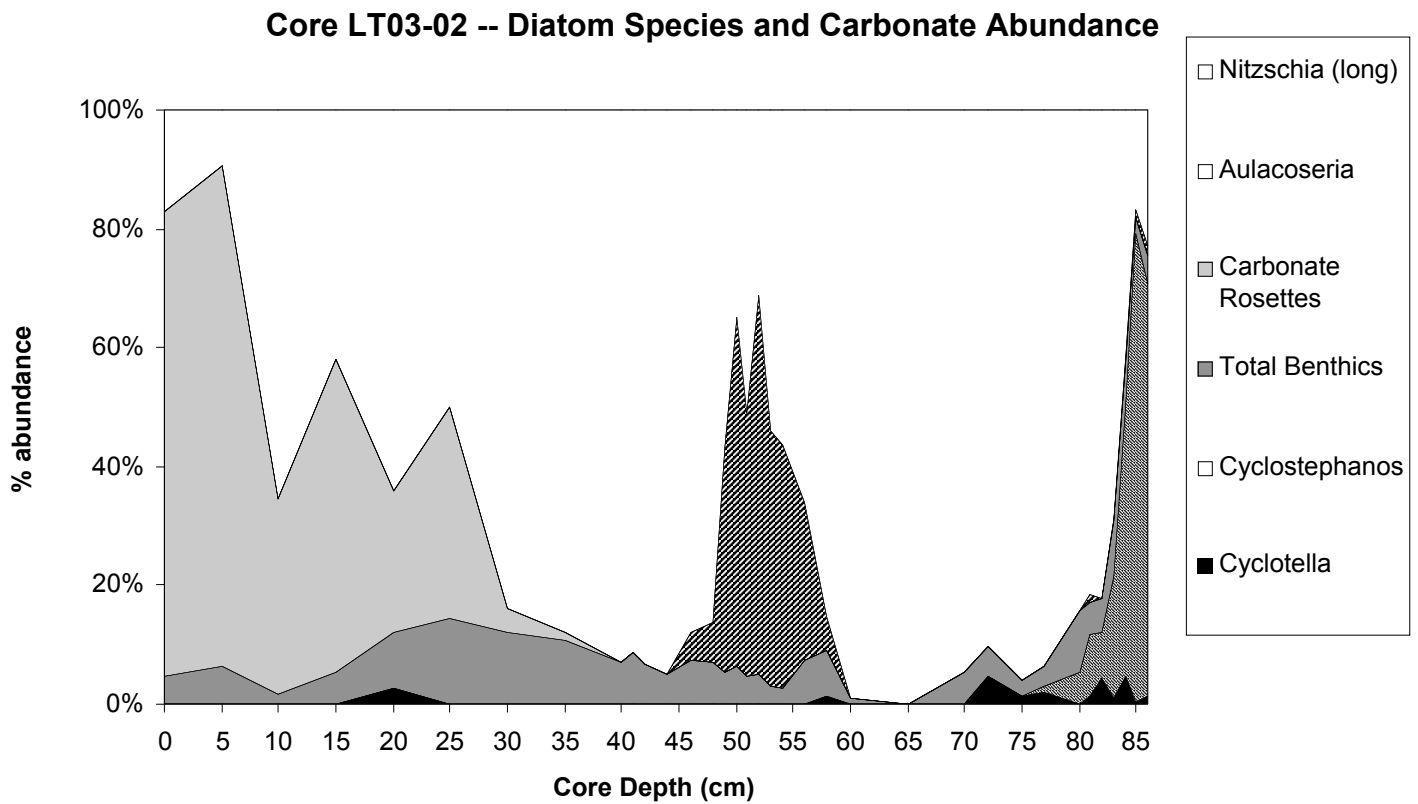


Figure 1