

Paleolimnological Reconstruction of Late Holocene Paleoclimate via Foraminifera Assemblages and X-Ray Fluorescence

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Summary

The increased frequency and intensity of weather events and changes to synoptic rainfall are some of the many implications that accompany the changing climate. There have been many studies focused on regions in the western North Atlantic which attempt to reconstruct paleoclimate records to improve modern predictions of climate. This study investigates microfossil assemblages and implements X-ray fluorescence elemental analysis (XRF) to produce a high-resolution Late Holocene paleoclimate record for two ponds on San Salvador Island, Bahamas. Fluctuations of precipitation patterns and salinity were identified via microfossil diversity and correlated well with the Chloride record produced via XRF. Results were compared with previous works investigating paleoclimate within the Caribbean, highlighting the potential of Chloride as a proxy for paleoclimate and salinity.

Theory

As global climate change continues to evolve, extreme weather events and other related outcomes continue to intensify almost unpredictably. Global sea surface temperature has risen and with that, storm intensity and duration (Trenberth, 2005). Subtle changes to sea surface temperature and atmospheric circulation in the Caribbean have strong influence on climatic conditions within surrounding regions and into North America (Gregory et al., 2015). Thus, the reconstruction of paleoclimate records throughout the Holocene can provide better predictions for future climate (Gregory et al., 2015).

Marine-lake basins can provide excellent sedimentary archives for paleoclimate (Burnett et al., 1989). Their proximity to deep-water seaways and sea level allows these lakes and ponds to respond quickly to subtle changes in regional climate (Burnett et al., 1989). Fluctuations in salinity within these coastal basins can be attributed to changes in sea level and freshwater input, isolating the effects of climate change (ie. wet and dry periods) (Gregory et al., 2015). The investigation of microfossil assemblages such as foraminifera is one technique often applied for studies of paleoclimate due to their predictable responses to environmental change (Gregory et al., 2015). Another common method utilised in past research is X-ray fluorescence (μ XRF) core scanning, which measures trace element composition of sediment and reflects precipitates in the water column, deposited mineral material, and solutes in the water scavenged by organic clay and flocculants (Gregory et al., 2015). The trace elements can then be connected to depositional conditions such as precipitation and salinity (Gregory et al., 2015). Analyzing chemostratigraphy of fine grained sediments via μ XRF has been previously established to demonstrate changes in precipitation patterns (Gabriel et al., 2022). A combination of these techniques provides insight to specific environmental conditions, namely precipitation and salinity, which can reflect paleoclimate trends within the region (Gregory et al., 2015).

Results

Within the scope of an Honours thesis, two sediment cores collected in San Salvador Island, Bahamas from two ponds were analyzed via foraminifera assemblages as well as μ XRF core scanning. Results of both microfossil and elemental concentrations correlated well with previously hypothesized wet and dry periods throughout the Late Holocene (ie. Sullivan et al., 2022; Gregory et al., 2015; Park et al., 2012; Liu & Fearn, 2000). As well, the high resolution record produced for Chloride (Cl) via μ XRF was found to correlate very well between the two ponds, despite their differences in lithology. This relationship held true when compared with $\delta^{18}\text{O}$ data from sediment cores collected in Lake Miragoane, Haiti (Hodell et al., 1991), indicating the potential ability of Cl as an indicator of paleoclimate parameters including precipitation and salinity. As μ XRF is an efficient and already popular method, the potential to use Cl as a proxy to reflect rainfall and salinity would be a practical technique that would produce high resolution records across long time scales.

Additive Information

Further research will continue to investigate the ability to utilise Cl as a proxy for paleoclimate. Investigating the relationships of Cl with sea surface temperature, precipitation and evaporation data and known TC events will further solidify its potential as a proxy. Along with continued research within the Bahamas, the Yucatan Peninsula in Mexico will be studied. This area has been another common location for studies of paleoclimate due to the abundance of coastal Quaternary deposits on the karstified limestone platform (McNeill-Jewer et al., 2019). Samples collected via sediment traps within the Yax Chen Cave System within the Yucatan Peninsula will be analyzed through the utilization of similar methods to those in San Salvador to further investigate the potential of Cl as a proxy for Late Holocene paleoclimate and synoptic rainfall.

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