Geochemical Proxies for Environmental Change in Lake Pupuke, Auckland, New Zealand

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ABSTRACT

Lake Pupuke is a fresh water maar lake located on the North Shore of Auckland City, New Zealand. Accumulated sediments within Lake Pupuke represent a high-resolution, continuous record of change from crater formation (ca. 200 kyr) to present. This study represents a component of the ongoing NZ-Maar project which aims to establish a reliable high-resolution Late Quaternary climatic history for the Auckland region based on multi-proxy investigations of the Auckland maar lakes.

Here a multi-proxy record from Lake Pupuke sediment spanning the last ca. 48 cal. kyr BP is presented. Chronological control for the sequence was established using a mixed-effect regression age-depth model based on tephra and radiocarbon age markers (n = 11, 13). The multi-proxy approach adopted here focuses primarily on the lipid biomarker composition and compound-specific isotopic analysis of sedimentary organic matter. Compound groups analysed included the n-alkanes, n-alkanoic acids, n-alkanols, sterols and triterpenoid hydrocarbons, which included botryococcenes derived from the algae *Botryococcus braunii*. In addition to these molecular proxies, a suite of geochemical (TOC, TN, TS, $\delta^{13}C$, $\delta^{15}N$, ITRAX) and physical (water content, bulk density, mass accumulation rate, magnetic susceptibility) proxies were also employed in order to produce a complete palaeoenvironmental dataset.

$\delta^{13}C$ variability in Lake Pupuke sedimentary organic matter is driven by aquatic organic matter sources, with terrestrial biomarkers exhibiting only minor $\delta^{13}C$ variation consistent with an exclusively C_3 catchment vegetation. The principle control on aquatic biomarker $\delta^{13}C$ is attributed to the availability of $[CO_2]_{aq}$ and exhibits strong links pCO_2, particularly during the Last Glacial Coldest Period (LGCP) where a low in pCO_2 corresponds to enriched $\delta^{13}C$ composition.

A combination of multi-proxy inferences on organic matter sources, catchment erosion, biological productivity, lake redox and palaeoprecipitation indicate that the LGCP commenced of the LGCP ca. 29.6 cal. kyr BP, during which Auckland experienced a colder, dry climate with harshest conditions cantered at ca. 23.5 to 21 cal. kyr BP and 19.3 to 18 cal. kyr BP. Termination I commenced at ca. 18 cal. kyr BP marking the transition to warmer temperatures during the Last Glacial-Interglacial Transition (LGIT). High algal productivity between 14.2 and 12.5 cal. kyr BP likely represent a warmer interval while precipitation is seen to gradually increase after ca. 13.4 cal. kyr BP. The early Holocene (ca. 10 to 7.5 cal. kyr BP) exhibits warmest conditions and a significant increase in seasonality is observed after ca. 7 cal. kyr BP, including a greater climate variability between 5.2 and 2 cal. kyr BP that reflects El Niño Southern Oscillation (ENSO) intensification.

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Table of Contents

Table of Contents

Table of Contents

Table of Contents

List of figures

List of figures

List of figures

List of figures

List of figures

List of tables