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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 botryococcones derived from the algae *Botryococcus braunii*. In addition to these molecular proxies, a suite of geochemical (TOC, TN, TS, $\delta^{13}\text{C}$, $\delta^{15}\text{N}$, ITRAX) and physical (water content, bulk density, mass accumulation rate, magnetic susceptibility) proxies were also employed in order to produce a complete palaeoenvironmental dataset.

$\delta^{13}\text{C}$ variability in Lake Pupuke sedimentary organic matter is driven by aquatic organic matter sources, with terrestrial biomarkers exhibiting only minor $\delta^{13}\text{C}$ variation consistent with an exclusively C_3 catchment vegetation. The principle control on aquatic biomarker $\delta^{13}\text{C}$ is attributed to the availability of $[\text{CO}_2]_{\text{aq}}$ and exhibits strong links $p\text{CO}_2$, particularly during the Last Glacial Coldest Period (LGCP) where a low in $p\text{CO}_2$ corresponds to enriched $\delta^{13}\text{C}$ composition.

A combination of multi-proxy inferences on organic matter sources, catchment erosion, biological productivity, lake redox and palaeoprecipitation indicate that the LGCP commenced at ca. 29.6 cal. kyr BP, during which Auckland experienced a colder, dry climate with harshest conditions centered 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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