A Diatom Stable Isotope Paleolimnology of Lake Pupuke, Auckland, New Zealand

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ABSTRACT

High-resolution, continuous environmental records spanning the late Quaternary are scarce from the mid-latitudes of the SW Pacific sector of the Southern Hemisphere. However, detailed sedimentary records of the late Quaternary exist in Auckland's volcanic crater (maar) basins. The purpose of this study is to reconstruct a continuous, high-resolution record of paleoclimate from an Auckland maar, Lake Pupuke, through: (1) the construction of a detailed tephra and radiocarbon-based chronology; (2) application of a suite of proxies for environment including novel diatom stable isotopic proxies ($\delta^{18}O_{Diatom}$ and $\delta^{30}Si_{Diatom}$); and (3) a multi-proxy reconstruction of paleolimnology from ~48 cal. kyr BP until today.

A mixed-effect regression age-depth model was constructed from tephra and radiocarbon age-markers (*n* = 11, 13 respectively), permitting reconstruction of paleoclimate at Lake Pupuke during the last ~48 kyrs (~14 m) from biological (diatom), geochemical (TOC, TN, TS, $\delta^{13}C$, $\delta^{15}N$, ITRAX) and physical (magnetic-susceptibility, particle-size distribution) proxies for environmental and limnological change. Paleoclimatic inferences are made from $\delta^{18}O_{Diatom}$ and $\delta^{30}Si_{Diatom}$ proxies following a *novel* approach to tephra-contaminant removal involving physical separation and geochemical mixture modeling. Estimates of the Oxygen and Silicon contributed by basalt and rhyolite contaminants were combined with representative $\delta^{18}O$ and $\delta^{30}Si$ signatures to yield a basaltic and rhyolitic isotope effect. Once removed, this yielded tephra-free estimates of $\delta^{18}O_{Diatom}$ and $\delta^{30}Si_{Diatom}$ for the Pupuke paleo-record from ~48 cal. kyr BP until today.

A synthesis of multi-proxy inferences on erosion, biological productivity, mixing and lake level generates robust dates for the onset of reduced effective precipitation and cooling in the Last Glacial Coldest Phase (LGCP; ~28.5-18.5 cal. kyr BP), a return to warmer, wetter climate in the Last Glacial-Interglacial Transition (LGIT; 18.5-10.2 cal. kyr BP), and warmest conditions in the Holocene (post-10.2 cal. kyr BP). The LGCP, LGIT and Holocene exhibited marked paleoclimatic variation at Lake Pupuke, including harshest paleoclimate near the onset and termination of the LGCP (~27.6-26.0 and ~21.0-19.0 cal. kyr BP), a Late Glacial Reversal in climate amelioration (LGR; ~14.5-13.6 cal. kyr BP) and a Holocene rise in seasonality (from ~5.7 cal. kyr BP, intensifying from ~3.2 cal. kyr BP).

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

ACR	*Antarctic Cold Reversal*
AVF	*Auckland Volcanic Field*
BSi	*Biogenic Silica*
CONISS	*Constrained Incremental Sum of Squares*
C/N	*Ratio of organic carbon relative to nitrogen*
DBD	*Dry Bulk Density*
DCA	*Detrended Correspondence Analysis*
DO	*Dissolved Oxygen*
DIC	*Dissolved Inorganic Carbon*
DI-Chl a	*Diatom-Inferred Chlorophyll a*
DI-DRP	*Diatom-Inferred Dissolveable Reactive Phosphorus*
DI-EC	*Diatom-Inferred Electrical Conductivity*
DI-pH	*Diatom-Inferred pH*
DI-TP	*Diatom-Inferred Total Phosphorus*
DSi	*Dissolved Silica*
FTIR	*Fourier-Transform Infra-Red*
GMWL	*Global Meteoric Water Line*
LEL	*Local Evaporation Line*
LGCP	*Last Glacial Coldest Period*
LGM	*Last Glacial Maximum*
LGR	*Late Glacial Reversal*
LGIT	*Last Glacial-Interglacial Transition*
LMWL	*Local Meteoric Water Line*
MAR	*Mass Accumulation Rate*
MER	*Mixed Effect Regression*
MIS	*Marine Isotope Stage*
MS	*Magnetic-susceptibility*
OM	*Organic Matter*
PCA	*Principal Components Analysis*
RMSEP	*Root mean squared error of prediction*
SAR	*Sediment Accumulation Rate*
SPLITT	*Split-flow laminar fractionation*
TOC	*Total Organic Carbon*

TN	*Total Nitrogen*
TP	*Total Phosphorus*
TS	*Total Sulphur*
WA-tol	*Weighted Averaging with tolerance down-weighting*
WA-PLS	*Weighted Averaging partial least squares*
WBD	*Wet Bulk Density*
W_c	*Water Content*
YD	*Younger Dryas*