Integrated age modelling of numerical, correlative and relative dating of a long lake sediment sequence from Orakei maar palaeolake, Auckland, New Zealand

Leonie Peti[1,*], PC Augustinus[1], D Fink[2], T Fujioka[2], C Mifsud[2], A Nilsson[3], R Muscheler[3], KE Fitzsimmons[4], JL Hopkins[5]

1 School of Environment, University of Auckland (New Zealand), 2 Australian Nuclear Science and Technology Organisation (Australia)
3 Department of Geology, Lund University (Sweden) 4 Terrestrial Palaeoclimates, Max Planck Institute for Chemistry (Germany)
5 School of Geography, Environment and Earth Sciences, Victoria University of Wellington (New Zealand)
* email: lpet986@aucklanduni.ac.nz; twitter: @LeoniePeti

Background

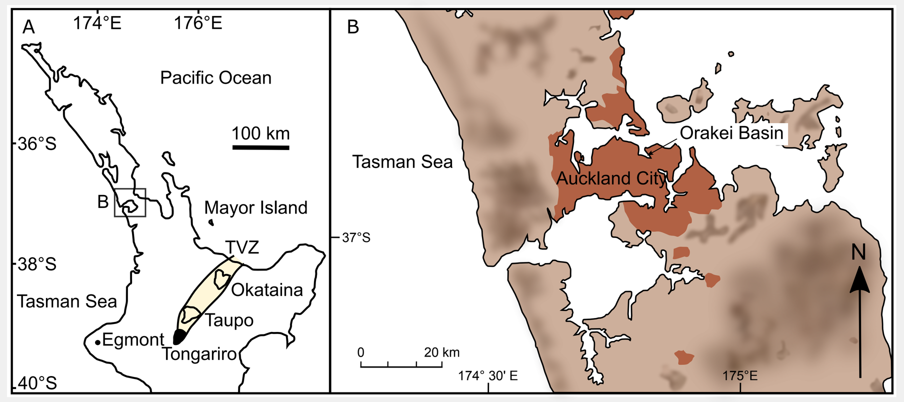

Figure 1: Orakei Basin on New Zealand's North Island north of large volcanic centres (A) is located in Auckland City (B).

Auckland maar lake sediment [1] (Orakei Basin here) provides continous, high-resolution records of climatic change over the last Interglacial (ca. 130 ka). 80 m of lacustrine sediment offer insight into a-/synchrony of climate change events, inter-hemispheric teleconnections and climate change in the under-studied SW Pacific region. However, a multi-method approach to obtaining robust chronologies is crucial and specifically focuses on the record older than the radiocarbon dating limit.

Methods

- 19 organic macrofossils, 7 bulk sediment samples AMS-^{14}C dated (SHCAL13)
- Bulk sediment samples corrected with a facies-dependent reservoir effect (410 and 1230 yrs)
- ^{14}C ages integrated with 5 dated tephra layers and Laschamp excursion for age model <50 ka
- 6 single-aliquot post-IR $IRSL_{290}$ ages on polymineral feldspars (4 - 11 µm) >50 ka
- Age model generated in Bacon 2.3.7 [2] (model specifications see Fig. 2) with extrapolation for basal 4.83 m
- Age-depth spline fine-tuned via dynamic time warping of magnetic relative palaeointensity (477 cube samples; NRM/ARM @20mT Lund)

Orakei age-depth model

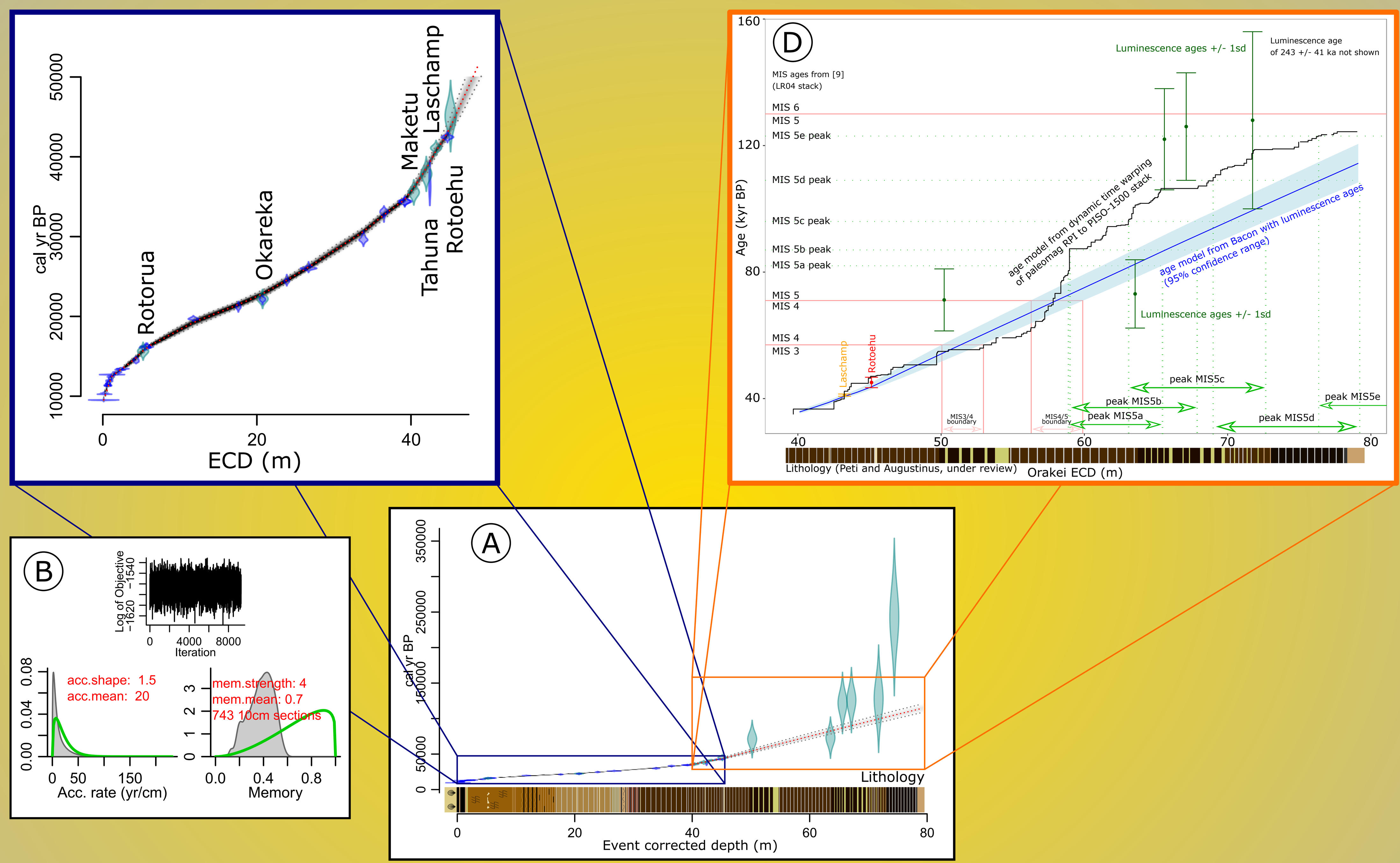

Figure 4: Complete, integrated Orakei age-depth model. A: Total age model based on 14C ages, tephra layers, Laschamp excursion, and luminescence ages. B: Enlarged <50 ka section of the age-depth model. C: Bacon model prior and posterior information. D: Age-depth spline for the >40 ka section of the Orakei age model after fine-tuning by palaeomagnetic field strength variation (see below).

Palaeomagnetism and correlative dating

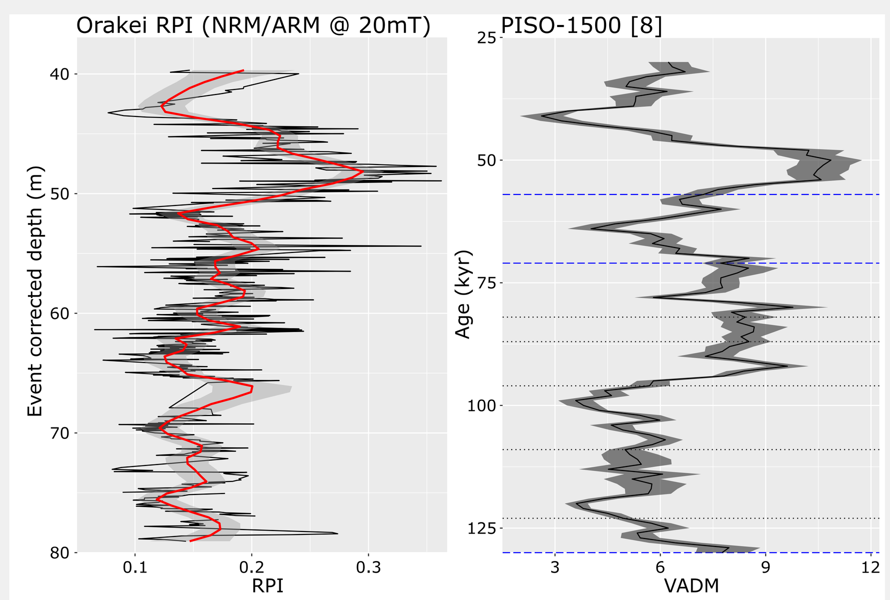

Figure 2: Comparison between Orakei relative palaeointensity (RPI) and VADM from PISO-1500 [8].

Broad-scale variation in the Earth's magnetic field are of global nature and thus proxy data of palaeo-magnetic field strength (RPI, ^{10}Be flux) allows tuning of the Orakei record to the global PISO-1500 stack (Fig. 2). Dynamic time warping finds a warping path of lowest cost that stretches and compresses the query vector to match the reference vector.

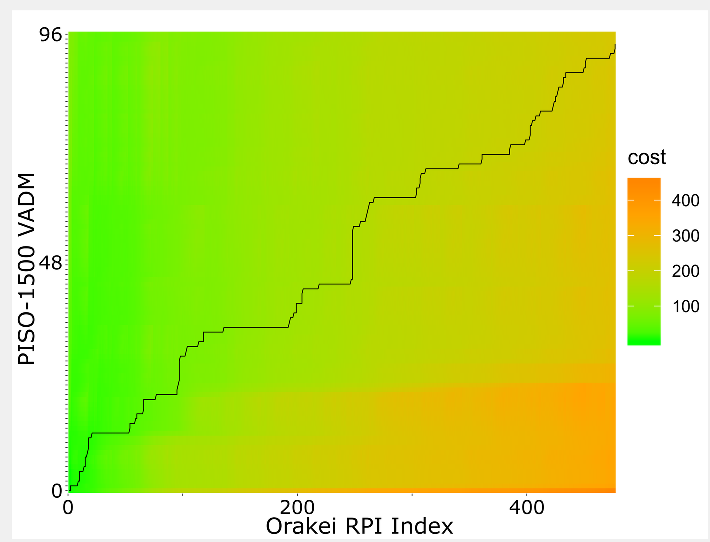

Figure 3: Cost-Matrix resulting from dynamic time warping alignment of Orakei RPI and PISO-1500 with warping path.

Conclusions

The Orakei sediment sequence clearly highlights the importance of robust age models and consideration of (often large) uncertainties. However, through careful integration of a multitude of techniques (luminescence dating, palaeomagnetic field strength, tephrochronology and radiocarbon dating) it is possible to arrive at a reasonable age model which may be refined by environmental observations (such as clear warm/cold stages from pollen data or stable isotope variation).

Reduced uncertainties on the luminescence ages, a better understanding of the reservoir effect in the Orakei and other deep maar lakes, as well as improved incorporation of uncertainties into correlative dating are necessary for future improvements on chronology development.

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