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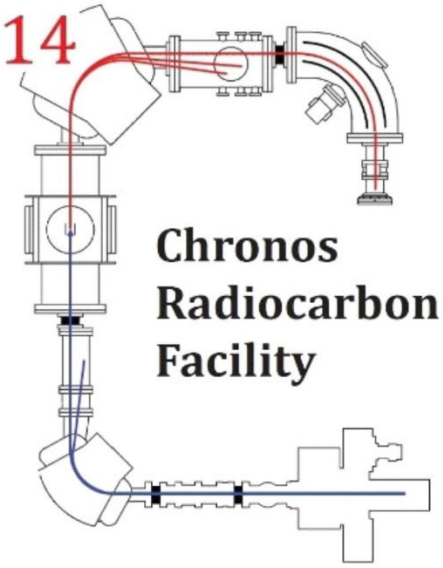

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ORALS

Climate steered humans into the southern Levant 70–40 ka.

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Environmental drivers were likely key to human dispersals from Africa into and throughout Eurasia, but the effect of such drivers on human biogeography has yet to be resolved at high-resolution on a regional scale. Here, we probe the Levantine-Arabian region for environments favourable to human forager groups around 50 ka when a demographic wave surged across Eurasia imprinting the ancestry of all non-Africans living today.

We present a set of 33 optically stimulated luminescence dates demonstrating more than 50,000-years of persistent riverine wetlands on the eastern margin of the Jordan Rift Valley at Hamra Faddan and Wadi al-Hasa—the latter hosting stratified Middle Palaeolithic artefacts indicative of frequent human presence. By reviewing and combining multiple climate proxy records, our analysis reveals permanent surplus moisture existed across much (~70,000 km^2) of the southern Levant during the interval 70–40 ka, in contrast to surrounding regions such as interior Arabia where intensified aridity and a paucity of archaeological sites primarily suggest landscape abandonment.

We propose that the southern Levant offered a relatively stable, favourable environment for foraging human populations extending to the Upper Palaeolithic, during which time the region was a crucible for fostering human admixture, knowledge sharing and technological evolution. The southern Levant likely functioned as one of several population and cultural hubs in Southwest Asia during the Late Pleistocene.

Silicate weathering and climate feedbacks at orbital timescales.

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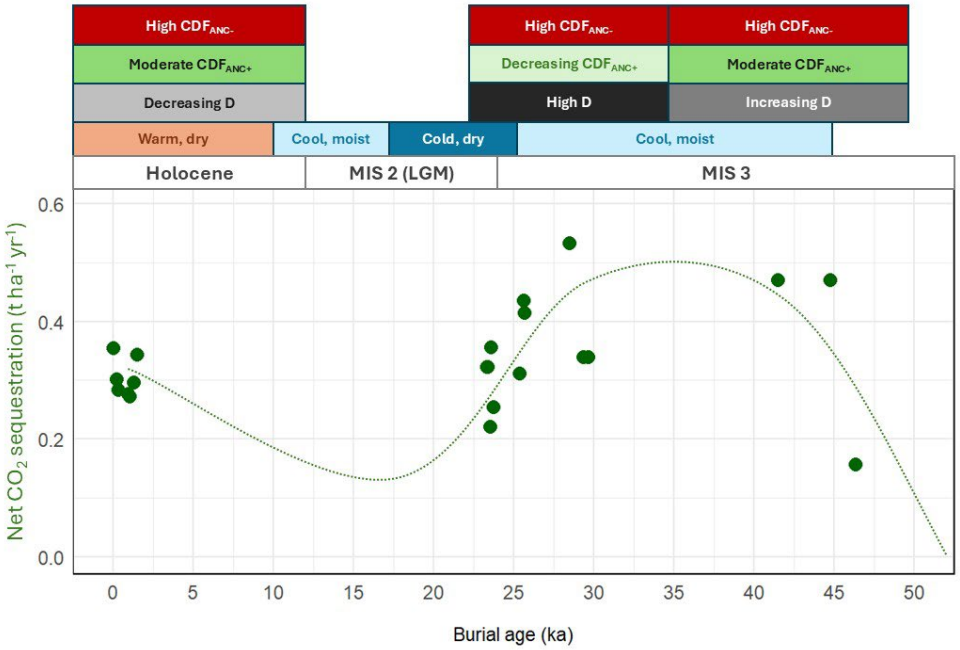
Silicate weathering is a key geological pathway for long-term CO_2 removal, converting atmospheric carbon into dissolved carbonate alkalinity. This process provides a negative climate feedback, whereby increased GHG climate forcing enhances silicate weathering and consumes atmospheric CO_2; modelling studies suggest it damps climate perturbations over 10^4–10^5-year timescales. Here, we test (1) the climate sensitivity of silicate weathering; (2) response timescales; and (3) the strength and sensitivity of climate feedbacks over orbital timescales. Our study is in the Oregon Coast Range where long-term uplift (0.1–0.3 mm y^{-1}) and erosion generate hillslope soils with short residence times and abundant weatherable minerals. We use an archive of eroded hillslope soil at Little Lake spanning the last ca. 40 ka to estimate the flux of carbonate alkalinity and hence CO_2 drawdown. A flux of dissolved inorganic C (DIC) was estimated from the state of weathering of the sediment relative to the bedrock (Tyee Formation), scaled by the soil production rate (estimated from cosmogenic ^{10}Be) assuming steady state hillslope erosion. We estimated alkalinity generated via weathering by calculating excess positive charge in the balance of conservative cations and anions released during bedrock–soil conversion, and equating that to HCO_3^-; then scaled by the soil production rate. Finally, we compared the DIC flux (= CO_2 consumed) to paleoclimate records from pollen analysis. Contrary to expectations, CO_2 sequestration was greatest in MIS3 and lower in both MIS 2 and the Holocene (MIS1). This pattern arose because of increased denudation rate in MIS3 due to enhanced frost cracking, while chemical weathering rate remained moderate. The low chemical weathering rate of MIS2 overwhelmed increased mineral supply to bring about lower CO_2 drawdown. Despite high chemical weathering rates in the Holocene, lower denudation rate brought about a supply limitation to the flux of alkalinity.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Moderate CDF$_{ANC+}$
Decreasing D
High CDF$_{ANC-}$
Decreasing CDF$_{ANC+}$
High D
High CDF$_{ANC-}$
Moderate CDF$_{ANC+}$
Increasing D
Warm, dry
Cool, moist
Cold, dry
Cool, moist
Holocene
MIS 2 (LGM)
MIS 3
Net CO_2 sequestration (t ha^{-1} yr^{-1})
0.6
0.4
0.2
0.0
0
5
10
15
20
25
30
35
40
45
50
Burial age (ka)

Diatom-salinity transfer function and climate-ecological interactions in south-west Western Australia.

Aukes, Teye[1]; Tibby, John[1]; Tyler, Jonathan[1]; Perez, Vilma[1]; McGrath, Gavan[2]; Venarsky, Mike[2]; Boesl, Fabian[3]; Jacobsen, Geraldine[4]; Child, David[4]; Maizma, Sabika[4]; Hotchkiss, Michael[4]; Gadd, Patricia[4];

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South-west Western Australia (SWWA) is known for its nature and agricultural activity. Its biodiversity is characterised by high levels of endemism and is one of 36 globally recognised biodiversity hotspots. The region's Mediterranean climate is characterised by warm, dry summers and cool, wet winters. However, SWWA winter precipitation has declined by 10 – 20% since the 1970s, affecting people, agriculture and biodiversity by reducing water availability, streamflow and groundwater recharge. Due to the scarcity of high-resolution records in the area, there is little known about how (hydro)climate in this region has varied through the Common Era. This is further complicated by a relatively short instrumental period, further highlighting the debate whether the recent change is unprecedented or not. In order to understand the adaptability of the region to changes in precipitation and to aid policymakers, it is necessary to understand past climate variation and ecosystem responses.

To assess SWWA climate variability, diatoms and water quality data from over 40 lakes (conductivity between 200 – 3900 µS/cm) on the south coast of south-west Western Australia were sampled to construct a diatom-salinity transfer function, which was applied to a record from Boat Harbour Lagoon. Diatoms found within the modern samples and sediment records are generally cosmopolitan, with interesting taxa, such as Eunophora sp., present in certain lakes. This talk focusses on the construction of a diatom-salinity transfer function for south-west Western Australia using modern lake samples. McHugh (2004) and Taukulis (2007) have previously constructed a transfer function in the region but focussed on lakes from the Swan Coastal Plain and on more saline lakes further north-west instead of on freshwater lakes from the south coast. The transfer function will be applied to Boat Harbour Lagoon for a preliminary palaeoclimate analysis, including covering dating methods using radiocarbon, total Pu and Pu isotopes, and Pb-210.

Vegetation and disturbance dynamics on King Island: a spatially replicated palaeoecological reconstruction.

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Agricultural land clearing has transformed many island ecosystems, yet long-term records capable of separating natural variability from post-colonial ecological change remain rare. King Island (western Bass Strait, Lutruwita/Tasmania) provides a compelling case study: the island supports threatened vegetation communities and critically endangered subspecies dependent on mature forest habitat, despite extensive landscape modification since European colonisation.

Here we present a spatially replicated palaeoecological reconstruction based on five lake sediment cores distributed across contrasting catchments. Pollen, charcoal, and sedimentary carbon and nitrogen analyses reconstruct vegetation composition, fire activity, and ecosystem dynamics over the past ~2,000 years, with particular focus on ecological change since European settlement. Historical aerial photographs (1950s–present) and satellite imagery are analysed using GIS to quantify land-cover change and wetland modification, enabling direct comparison between sedimentary records and documented phases of agricultural intensification.

This multi-site approach provides the first island-wide reconstruction of vegetation and fire dynamics for King Island. By testing whether post-colonial transformation exceeds pre-colonial variability, the study establishes empirical ecological baselines to inform conservation, restoration, and fire management in a highly fragmented agricultural landscape.

Holocene climate and environmental reconstructions from speleothems in the Cook Islands.

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Speleothems in the Cook Islands are excellent climate and environmental archives in a region where rainfall is primarily controlled by shifts in the South Pacific Convergence Zone (SPCZ). Here we present a composite multiproxy record from an ample collection of stalagmites and flowstones retrieved from four shallow caves in the island of Atiu covering the last 14,000 year.

The speleothems are characterised by unusually high and variable initial $^{230}Th/^{232}Th$ ratio that renders the U-series dating particularly challenging. For this reason, the age models were implemented by combining radiometric (U-series, ^{14}C) and annual lamina counting methods (Faraji et al., 2023), while optical and fluorescence microscopy coupled with high-resolution LA-ICP-MS trace element analyses and synchrotron XRF mapping allowed identifying flood events, hiatuses, and condensed growth intervals.

The interpretation of climate and environmental proxies was facilitated by a multi-year rainwater and cave monitoring program (Faraji et al., 2022), and by in-situ nucleation experiments and calcite farming (Frisia et al., 2022). Overall, the speleothems geochemical and textural properties are influenced by prior calcite precipitation, which causes large positive shifts in $\delta^{13}C$ and $\delta^{18}O$ values as well as enrichment in hydroclimate sensitive elements Mg, Sr, Na (Faraji et al., 2024) allowing reconstructing the infiltration, which is controlled by the ENSO dynamic.

However, the speleothem proxies are also sensitive to storm events, tropical cyclones, and groundwater level fluctuations. Furthermore, seismic events triggered both growth interruptions and abrupt shifts in trace elements concentration. Critically, the proxy records in the last millennium are strongly imprinted by human activity, both outside and inside the caves. Ultimately, this rich speleothem collection studied within two ARC Discovery Projects provides a wealth of information that is far from being fully investigated.

Long-term climate and carbon dynamics from eastern Australian lacustrine sediments: MIS5 to present.

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[6] School of Geography, University of Nottingham, Nottingham, United Kingdom;
[7] School of Earth and Atmospheric Sciences, Queensland University of Technology, Brisbane, Queensland, Australia;
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The last glacial cycle is a key period in the environmental and cultural history of the Australian continent, yet the climate of this time period remains poorly understood. Conflicting evidence from spatially disparate lacustrine records and discontinuous fluvial archives have hindered consensus on environmental change during this period. Here, we present two new, highly resolved organic sedimentary records from the Thirlmere Lakes (NSW) and Minjerribah (North Stradbroke Island, QLD) regions of eastern Australia that provide new constraints on long-term climate and environmental variability through the last glacial cycle.

Australian aquatic systems often deviate from biogeochemical frameworks developed largely from Northern Hemisphere environments. The prevalence of low-nutrient conditions results in unusual carbon isotope signatures, complicating the identification of organic carbon sources and their transport between terrestrial and aquatic reservoirs. Through characterisation of modern aquatic carbon isotopes, we develop alternative threshold values for distinguishing organic matter sources and, in turn, demonstrate the utility of

sedimentary stable carbon isotopes as robust tracers of environmental and climatic change in southern mid-latitude systems.

Applying these newly developed isotope thresholds, we reconstruct millennial-scale climate variability in eastern Australia from Marine Isotope Stage 5 to the present. The resulting records reveal strong coupling between regional carbon cycling and Southern Hemisphere high-latitude climate, with limited evidence for Northern Hemisphere forcing. These findings highlight the importance of regionally calibrated carbon isotope frameworks and demonstrate the value of stable carbon isotopes for reconstructing past Earth system change in under-represented Southern Hemisphere environments.

Climate Change Driven Persistence Changes in Australian Snowpatches.

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Snowpatches play a key role in alpine and high latitude environments and are highly vulnerable to climate change, particularly where, as in the Australian Alps, there is no nival zone where they and their dependent vegetation communities can retreat.

A mix-methods approach was used to identify and understand long-term trends and changes in persistence for 43 snowpatches in the Snowy Mountains and Victorian High Plains of South-eastern Australia. An eXtreme Gradient Boosting (XGBoost) model with SHapley Additive exPlanations (SHAP) analysis was applied, and partnered with satellite and snow course data, proved highly effective in identifying and ranking key drivers of snowpatch persistence, demonstrating the relative importance of spatial rather than temporal factors, and of the importance of fetch, elevation, peak snow depth, snow metre days, and ablation season temperature. The long-term decline in snowpatch persistence is attributed to global warming induced changes in the regional climate, with fluctuations in inter-annual variability in persistence caused by complex interactions between regional climate drivers.

Changes in the mean day of year ablation date for surveyed snowpatches were applied to the preferred snow cover ranges of snowpatch dependent vegetation communities, proving an effective means to show potential changes in these communities over time, and through imputation of snowpatch melt date into the future, of probable impending impacts to these highly vulnerable and critically endangered plant communities.

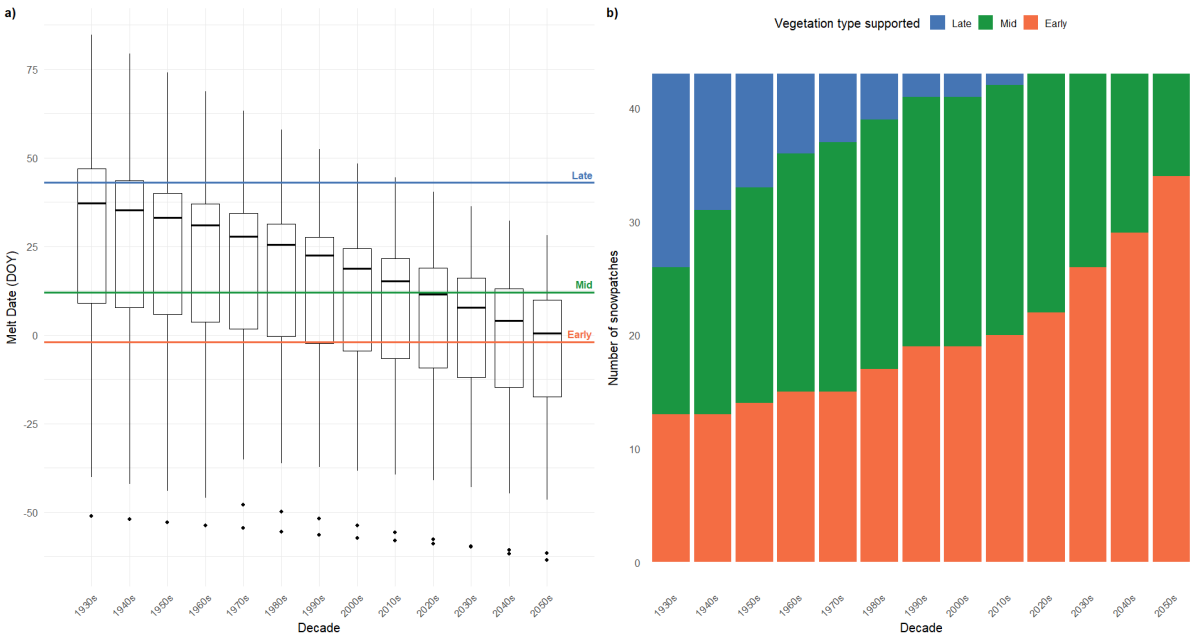

Figure: Mean melt date value (expressed as DOY) for each long snow-lie dependent plant community (after Pickering et al. (2014)) plotted against the decadal mean of snowpatch melt date. b) Relative change in the number of snowpatches meeting the mean melt day for each long snow-lie dependent vegetation community. The progressively earlier melt of snowpatches is increasingly favouring early and mid over late melt species, placing their future in doubt.

The montane peatlands of south-eastern Australia: From the Holocene to the Anthropocene.

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Peatlands cover 3% of the global land surface but are limited in extent within Australia (covering ~2.3 Mha). Throughout the Holocene, montane peatlands (freshwater systems >400 m asl) have persisted despite variable climatic conditions, ranging from higher effective moisture (Greenlandian) to cool, drier conditions (start of the Meghalayan). However, the occurrence of extreme climatic events (droughts, fires, and erosion) is predicted to increase in south-eastern Australia as we transition into the proposed Anthropocene (commencing ~1950s). Examination of three montane regions of south-eastern Australia, including Barrington Tops, the Blue Mountains, and Kosciuszko National Parks, sought to explore changes to peatland communities from the Holocene into the proposed Anthropocene. Individual peat cores were collected and dated using radioisotopes (radiocarbon, lead-210, total plutonium (^{239}Pu, ^{240}Pu and ^{241}Pu), and uranium-236), and pollen and macroscopic charcoal were analysed to investigate changes to peat landscapes over time. The study sites formed between 5,000 – 1,500 years BP, with the vegetation community being relatively stable and dominated by sedges (Cyperaceae) and shrubs (Myrtaceae and Ericaceae) characteristic of peatland communities. Charcoal prevalence and findings from age-depth modelling suggest that peat formation was interrupted with periods of fire, particularly within the Meghalayan. Charcoal varied between sites, peaking at the surface at the Blue Mountains and Barrington Tops sites, and at depth in Kosciuszko National Park. Radionuclide fallout associated with above ground nuclear testing peaked from 9 – 15 cm indicating Anthropocene commencement, with the introduced Pinaceae family occurring to depths of 25 cm. Whilst peatlands exhibit a degree of resilience, they remain vulnerable to degradation due to climatic events and human impacts. In the face of future climatic changes, it is of interest to understand how peatlands may change over time and risks posed to peat longevity.

Timing and magnitude of Holocene relative sea-level and coastal changes in Narrm/Port Phillip Bay.

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Understanding the timing, magnitude and behaviour of coastlines during past periods of rapid sea-level rise is crucial for examining future sea-level change. At the Last Glacial Maximum, Port Phillip Bay was an open plain where the Birrarung/ Yarra and Wirribi-yaluk/Werribee rivers flowed. Radiocarbon dating of sediment cores from the embayment show the post-glacial marine transgression began around 8,290 years ago (Holdgate et al., 2001). Earth-ice modelling suggests this part of the Australian coastline experienced a relative sea-level highstand of ~1.5 - 2m above present around 4000 -6000 years ago. One sea-level index point from Cape Liptrap supports this, an assemblage of fossilised barnacles dated at 6090-5880 years, were found in growth position on a coastal notch ~1.5m above present sea level (Gardner et al., 2009). A sediment record from Balcombe Creek also indicates the marine transgression began about 8000 years ago (Kennedy et al., 2020). Throughout this period of rapid coastal change and beyond Australia's First Nations People were living and cultivating this land, enhancing our understanding of the past landscapes may provide valuable information for cultural heritage. Presently, quantitative geological evidence for the Holocene marine transgression is limited to few studies. We compiled published and unpublished relative sea-level proxy data (with sufficient vertical and chronological resolution uncertainties) to generate a new paleo sea-level curve using a standardised approach (Khan et al., 2019). We also present the preliminary findings from new proxy data collected from three coastal wetlands around Port Phillip Bay on Bunurong country. Sedimentological analysis, and microfossil analysis (specifically foraminifera) alongside radiocarbon dating will be applied to reconstruct past coastal dynamics and relative sea-level changes. This project provides crucial understanding of the evolution of the Narrm/Melbourne coastline during the Holocene and can provide an analogue for examining future sea-level rise.

Halogens and rhenium as palaeosalinity proxies in marine and non-marine sediments, Gulf of Carpentaria.

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Affiliation/s

[1]School of Science, University of Wollongong NSW 2522.

During the past 130 ka the Gulf of Carpentaria oscillated between an open-ocean epicontinental sea and a perched lake, in response to sea level changes. The palaeoenvironments span all possible states to include saline lake, freshwater lake, hypersaline salt flat and subaerial exposure. Assemblages of ostracods, coccoliths, foraminifers, molluscs and charophytes define these major facies. The most recent lake phase, from about 60 ka until a marine transgression at about 12 ka, progressively freshened from initial marine to near-fresh. The minor clay minerals are diagnostic with glaucony being confined to marine facies and palygorskite, a magnesium-rich authigenic clay [$(Mg,Al)_5(Si,Al)_8O_{20}(OH)_2.8H_2O$], typical of alkaline non-marine conditions, increasing in abundance during the lake's evolution. We explore several whole-sediment geochemical indicators to estimate past lacustrine salinities as well as the simpler marine versus non-marine dichotomy. Core MD-32 was examined in detail supported by data from another three cores. From available analyses of about 80 elements, this work considers the halogens (F, Cl, Br, I) both in total-sediment and the water-soluble fraction. The latter is concluded to be similar to pore-water (now evaporated to dryness) analysis and is a reliable palaeosalinity indicator. Rhenium (Re), a transition metal in the same group as Mn, performs as well as the halogens in estimating palaeosalinity and is superior for highly saline marine waters. Rhenium is conservative in the marine environment as the soluble perrhenate ion (ReO_4^-) and invariant at about 8.3 pg/g (ppt), whereas world-wide fluvial input is also near-constant at about 3.3 ppt. This difference is sufficient to allow the analysis of the Re content of sediments as a measure of the mixing between fluvial input and residual ocean water within Lake Carpentaria. The actual contents are low, with fully marine sediments having ~3.8 ng/g (parts per billion) Re; hypersaline shoreline facies ~10 ppb, saline lake facies ~1ppb and the fresh lake phase 0.3 ppb. Re is easily determined by ICP-MS with a detection limit of 0.2 ppb in whole-sediment.

The mythical Lake George (Weereewa) and evidence for contrasting climate states driving pluvial conditions in SE Australia.

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Lake George – Weereewa is one of south-east Australia's iconic lake systems with exceptionally well preserved lake shorelines and a long Plio-Pleistocene sedimentary record on the lake floor. Galloway in his pioneering work on Lake George estimated that the lake could be full (up to 35 m deep) in glacial periods by decreasing regional evaporation and precipitation. Despite the important early work little has been done on unravelling the highest filling history or re-doing Galloway's original water balance calculations. Here we present the most comprehensive chronology of major lake margin landforms at Lake George. This includes constraining the age of the dominant alluvial plains on the eastern margin (which are graded to mid to high lake levels) and the highest shorelines including two 15 - 25 m cores through the Winderadeen embankment. Single grain quartz and feldspar OSL ages from the shorelines and the lake floor are combined with a recalculated water balance using catchment specific rainfall and runoff data. Our new data supports earlier estimates and shows that Lake George was at its fullest (37 m deep) during the Last Glacial Maximum (LGM) and that the Winderadeen embankment was built during Marine Isotope Stage (MIS) 4 - 2. However, we also show from elevated shorelines on the eastern margin that Lake George also filled to almost equivalent levels in MIS 5. Our re-calculated water balance data using the Lake George specific rainfall and runoff data also supports earlier estimations, suggesting reduced evaporation with reduced rainfall can lead to a positive water balance at Lake George.

A 37,000-Year Record of Savanna Fire Regimes from Kinrara Lagoon, Northeast Queensland.

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Fire is a key driver of ecosystem structure and function in Australian tropical savannas, yet high-resolution records documenting long-term fire–climate–vegetation-human interactions in the Southern Hemisphere are rare. We present a continuous 37,000-year palaeoenvironmental reconstruction from a 7 m sediment core recovered from Kinrara Lagoon, a spring-fed waterbody in northeast Queensland, providing new insights into how fire regimes have responded to climatic and human influences from the late Pleistocene to the present.

A robust chronology based on 17 radiocarbon dates constrains five stratigraphic units spanning 37,227 yr BP to the present. Fire history was reconstructed using complementary proxies that distinguish fire intensity, frequency, and fuel source. Pyrogenic carbon was quantified as stable polycyclic aromatic carbon (SPAC) using hydrogen pyrolysis to infer fire intensity, while charcoal particle analysis reflects local-to-regional fire occurrence. Stable carbon isotopes of SPAC (δ^{13}CSPAC) were used to determine the relative contributions of C_3 (woody) and C_4 (savanna grass) vegetation to biomass burning, alongside sedimentological indicators of lagoon processes.

The late Pleistocene (37,000–11,500 yr BP) was characterised by predominantly lithogenic deposition, low fire activity, and a transition from C_3- to C_4-dominated burning, consistent with progressive aridity through the Last Glacial Maximum. Lagoon formation in the early Holocene followed damming by Kinrara basalt flows and coincided with increased regional rainfall, wooded savanna expansion, and subdued fire regimes. The middle Holocene (8,750–3,600 yr BP) represents the warmest and wettest interval, with elevated but relatively stable fire activity punctuated by two intense episodes (~7,778 and 6,924 yr BP), likely linked to local volcanism. From ~3,600 yr BP, increasing hydroclimatic variability, consistent with ENSO intensification, corresponded with fluctuating carbonate deposition and fire regimes. Signals consistent with Indigenous landscape burning emerge after ~500 yr BP, followed by less frequent but more intense fires after European colonisation.

Improving climate-based predictions for the future of long-lived conifers.

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Rapid climate change and escalating wildfire activity are reshaping montane ecosystems worldwide, challenging the persistence of long-lived, fire-sensitive species. In temperate regions of the Southern Hemisphere, these pressures are particularly critical for relict conifers restricted to high-elevation environments. Gondwanan conifers such as Athrotaxis cupressoides (pencil pine), endemic to Tasmania's Central Highlands in Australia and currently listed as Vulnerable, exemplify these challenges. As a long-lived sub-alpine species with limited dispersal capacity and low fire tolerance, it offers a powerful natural model for examining how fire-sensitive conifers respond to coupled climatic and disturbance pressures over long timescales.

To evaluate these dynamics over appropriate ecological and climatic timescales, this study adopted a multiproxy palaeoecological approach integrating long-term vegetation, fire, and hydroclimate records. Palaeoecological data were combined with a speleothem-derived hydroclimate reconstruction spanning the Holocene to provide a millennial-scale perspective on interactions between moisture availability, fire activity, and conifer regeneration. The results demonstrate that persistently high moisture levels promote both reproduction and post-fire recovery of A. cupressoides, while long-term ecosystem trajectories strongly shape its present-day distribution. Projections under continued warming suggest contraction of suitable climatic niches in high-elevation regions, underscoring the vulnerability of montane conifers as fire regimes intensify.

To bridge deep-time dynamics with contemporary conservation planning, palaeoecological analyses were combined with species distribution modelling. Sites exhibiting long-term resilience correspond closely with areas of high climatic suitability today, while projections indicate uneven contraction of the species' climatic niche across its montane range.

By explicitly linking palaeoecological fire histories with species distribution modelling, this research advances methodological integration in fire ecology. It demonstrates how millennial-scale archives can inform contemporary resilience assessments, offering a transferable framework for conservation prioritisation in fire-prone ecosystems globally and

strengthening cross-disciplinary dialogue on wildfire-vegetation-climate interactions in a rapidly changing world.

Adaptability of Blue Heart Wetlands to Sea-Level Rise: Sunshine Coast, Queensland, Australia.

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Coastal wetland restoration offers nature-based solutions for climate change impact mitigation. The Blue Heart project was initiated by Sunshine Coast Council, Queensland, Australia to rehabilitate degraded agricultural land on the low-lying (<1 m Australian Height Datum) Maroochy River floodplains to coastal wetlands. We deployed a highly precise (1 mm accuracy) network of 24 Rod Surface Elevation Table Marker Horizon (RSET - MH) stations across coastal wetlands under different stages of development and rehabilitation to measure their surface (sedimentation rates) and subsurface (shallow subsidence, compaction or subsurface expansion) changes. Results showed that sediment accretion supports surface elevation in coastal wetlands under rehabilitation (CWUR). Radiocarbon dating of sediments from different depths (~ 40-170 cm) revealed CWUR holds Holocene-deposited mineral sediment (~2000–7000 Cal. Years BP). In addition, converting coastal forested areas such as Melaleuca forests to agriculture in past caused an elevation deficit (~ 0.9 m), which now provides accommodation space for incoming sediment. Therefore, Bayesian stable isotope mixing models showed that suspended particulate matter in tidal water dominates as sources of soil organic carbon (SOC) in CWCR. Whereas mature mangroves in Blue Heart source their SOC mainly from in-situ mangrove vegetation. Notable contributions from mangrove roots sustain the surface elevation in mature mangroves. In conclusion, CWUR in the Blue Heart can keep pace with current local sea-level rise (~ 2.1 mm $year^{-1}$) by elevating the land surface (4-15 mm $year^{-1}$), except for open-water areas (< 1 mm $year^{-1}$). In addition, contemporary sediment accumulation in CWUR provide opportunities for carbon abatement programmes.

Climate variability through the last interglacial period from multiproxy speleothem records from south-east France.

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The climate of the last interglacial was comparable to the warmer conditions projected for the coming decades. Understanding climate variability during this period therefore provides valuable context for future climate change. During the last interglacial, a series of meltwater pulses from Greenland entered the North Atlantic. However, the precise timing and terrestrial expression of these events remain poorly constrained. In order to understand their global impact, we first need to understand the climate response in the North Atlantic region. Here we present five temporally overlapping speleothem records from Saint-Marcel and Orgnac Caves in southern France spanning 138–105 ka. Together, these records cover Termination II, the last interglacial and the onset of the early last glacial period, at multidecadal to annual resolution. During the last interglacial, speleothem $\delta^{13}C$ reflects soil and vegetation productivity closely linked to temperature, whereas $\delta^{18}O$ records changes in precipitation. We investigate the timing and character of centennial- to millennial-scale climate variability and compare these patterns with coeval speleothem records from Italy and the Iberian Peninsula, as well as with North Atlantic marine records documenting meltwater pulses. The record also captures Termination II, during which the $\delta^{13}C$ soil and vegetation changes follow North Atlantic sea-surface temperature trends. The principal temperature shift marking the end of the termination is dated to 129.8 ± 0.5 ka. In contrast, $\delta^{18}O$ records a North Atlantic freshening signal associated with Heinrich Event 11. These replicated, high resolution and precisely dated speleothem records provide precise constraints on the links between the North Atlantic Ocean and western European climate, both during relatively short-lived centennial-scale events somewhat analogous to projected future changes and during the large-scale transition of Termination II.

Reconstructing the hydroclimate of north-west Australia since MIS 3 using floodplain sediments.

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There is a scarcity of continuous palaeoenvironmental records from monsoonal north-west Australia, particularly of those extending beyond the Holocene. This limits our understanding of long-term hydroclimate variability in this region – one of the major nodes of the global monsoon system. Consequently, there are significant gaps in our knowledge of how the monsoon has responded to past changes in sea level, ocean circulation and orbital forcing. Here we present records of hydroclimate, biological and landscape change developed from two floodplain cores from the eastern Kimberley. Together, and when considered alongside other regional records, the records provide a latitudinal assessment of the hydroclimate of north-west Australia since MIS 3. The similarity of the depositional environments (seasonally dry floodplain) allows for more direct comparisons than what might otherwise have been possible. Despite some variability between the records, they show that the present-day coastal landscapes and inland landscapes (e.g. 400 km inland) experienced broadly similar long-term (orbital scale) trends, as shown by periods of high and low sedimentation, but that there was much variation in lower resolution (millennial) hydroclimate between the two. The findings highlight the role of continentality in influencing the southern extent of the IASM, with the most sustained increases in wet-season precipitation occurring only after the marine transgression flooded much of the Sunda Shelf. Notably, the southern record, BD-FF, only began to closely track coastal hydroclimatic variability once both this flooding had occurred and the ITCZ had shifted furthest southward. Through the successful application of previously established methods to seasonally dry floodplain cores, this research has developed a prototype for future work on this type of archive. This advancement is particularly significant for research in arid and semi-arid regions, where obtaining reliable records has historically been challenging.

The Viability of a Rock varnish Chronology for dating Rock Art at Murujuga, Western Australia.

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Murujuga (Burrup Peninsula), located in the semi-arid Pilbara region of northwest Western Australia, hosts one of the largest and densest concentrations of rock art in the world, with over one million petroglyphs representing up to ~50,000 years of continuous human occupation. Establishing a reliable chronology for this rock art remains a significant scientific challenge, yet it is critical for understanding the timing of human activity across the Quaternary, particularly in relation to Holocene sea-level rise, climate change, and landscape evolution in northwest Australia.

Rock varnish, a thin ferromanganese accretion that forms on exposed rock surfaces, has long been proposed as a medium for dating rock art globally. However, its use as a reliable chronometer is contentious, and its viability depends on a thorough understanding of local varnish formation processes, geochemistry, and environmental controls.

In our recently published work, we present a detailed characterisation of rock varnish from Murujuga, examining its elemental and mineralogical composition, microstructure, and relationship to the underlying substrate lithology. We show whether varnish at this site preserves a coherent geochemical record that could be used to build a relative or numerical chronology for petroglyph production. Key findings reveal that varnish at Murujuga is likely biologically derived and thus may record environmental signals consistent with Holocene climate variability. However, important limitations are identified, including variability in varnish thickness and composition across lithologies, the influence of industrial air pollution on varnish chemistry, and the absence of a well-constrained local calibration dataset.

Highway 18 Revisited: fourteen years of field teaching and research in northwest Tasmania.

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For fourteen years, I have taken between 30 and 50 undergraduate and postgraduate students annually into the Surrey Hills and the Vale of Belvoir in northwest Tasmania as part of an intensive field-based teaching program. These landscapes occupy a singular place in Australian scholarship. They are among the key empirical foundations drawn upon by Rhys Jones in his landmark 1969 paper Fire Stick Farming, which permanently altered how archaeology, ecology, and environmental history understand Aboriginal fire use and landscape management.

The Surrey Hills were mapped in 1827 by the first European surveyor to enter the region as an extensive complex of treeless grasslands and open forests, and have long been regarded as an archetypal Aboriginal cultural landscape. This interpretation has been repeatedly reinforced by archaeology, palaeoecology, historical ecology and Aboriginal knowledge. Despite this long recognition, that history has been forgotten by contemporary Australia.

The same landscape is now depicted in Australia's pre-1750 National Vegetation Information System mapping as being dominated by closed forest prior to British invasion. This contradiction is not a minor technical disagreement. It exposes deeper structural problems in how environmental knowledge is produced and authorised in Australia. It reflects a blind faith in abstracted scientific models over historical evidence, a persistent ignorance of how Aboriginal people actively shaped and maintained Country for millennia, and the use of flawed environmental benchmarks to guide restoration, conservation, and national environmental accounting.

This long-term field teaching across the Surrey Hills and Vale of Belvoir allows students to confront these contradictions directly. Repeated visits expose limits of static maps, misplaced baselines, and enduring Aboriginal land management legibility. This talk reflects on how long-term field teaching has become a critical site for confronting the epistemic failures that underpin Australia's current environmental crises, and for re-centring history, Country, and care in environmental science.

Connecting Indo-Australian Monsoon and Palaeo-groundwater recharge by Land to Sea Drilling (CAMP L2S).

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In January 2026, a 'land to sea' (L2S) 'pre-proposal' was submitted to the 'International Continental Scientific Drilling Program' (ICDP) and the 'International Ocean Drilling Program-3 (IODP[3]), initiating a 7+ year pathway towards scientific deep drilling in the Gulf of Carpentaria and Lake Yamma Yamma (QLD). The main aim is to connect tropical palaeoclimatology in Australasia, controlled by global climate boundary conditions, sea level and oceanography, with palaeo-groundwater recharge in one of the world's largest artesian aquifer systems, the Great Artesian Basin (GAB).

The GAB, which underlies 22% of Australia, as well as overlying unconfined aquifers, are predominately recharged by Indo-Australian Summer Monsoon (IASM) precipitation, and tropical moisture further south. GAB recharge predominately occurs along the western slopes of Australia's east coast tablelands, and, to a limited degree, along the basin's western and north-western fringe. GAB groundwater can be up to 1-2 million years old due

to its size and slow water movements. However, the history and underlying mechanics of IASM-derived groundwater recharge in tropical to desert Australia remains unresolved. This is due to the lack of suitable deep-time, continuous palaeoclimate archives in the Southern Hemisphere that can inform on tropical monsoon precipitation, inland moisture supply via river runoff and atmospheric circulation, as well as tropical versus desert groundwater recharge history. Furthermore, the lack of deep time, Quaternary palaeoclimate archives in Australia hinders detailed reconstructions of inter-hemispheric interactions between Southern Hemisphere tropical to sub-tropical atmospheric circulation and the East Asian Monsoon system that affects more than 2.2 billion people. The sediments of the Gulf of Carpentaria, Lake Yamma Yamma, as well as underlying Cretaceous GAB sediments will facilitate reconstructions of IASM intensity, inland moisture transfer, and groundwater recharge in Australia's arid interior. It is proposed to use two distinctly different archives, namely sediment cores and groundwater data to develop independent, but complementary climate records to better understand long term dynamics of climate change, tropical flooding and groundwater recharge and depletion.

Stalagmites to link Australian climate and groundwater replenishment.

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Declining groundwater levels are currently being observed in many regions across the globe. Developing sustainable groundwater management plans requires predicting groundwater recharge under future climate scenarios. The first step in this process is drawing links between climate drivers and the replenishment of groundwater resources.

Groundwater level monitoring studies that are currently available do not offer adequate temporal coverage, and the recharge signal is typically obscured by extraction. Caves and other underground spaces positioned above the water table present an opportunity to observe potential groundwater recharge as it travels through the subsurface. Long-term cave monitoring datasets developed by our team for sites across southern Australia have been used to identify the timing and magnitude of rainfall events needed to trigger groundwater recharge under current climate conditions.

Speleothems offer a means of observing the relationship between groundwater recharge and climate beyond the instrumental era. In this study we use stalagmites to reconstruct groundwater recharge over the last millennium in water-limited, groundwater-dependent regions in southern Australia. Comparison of our recharge records to existing palaeoclimate records allows us to draw links between Southern Hemisphere climate drivers and local groundwater replenishment. Our findings, in conjunction with the modern monitoring data, will be used to constrain hydrogeological models that will be run on climate forecasts to predict groundwater recharge in southern Australia under future climate scenarios.

GDGT-based palaeotemperature reconstructions from lacustrine settings in Australia.

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To manage future climate variations and accurately determine environmental response, it is critical that we understand past temperature change, especially over the last 2000 years. Australian palaeotemperature reconstructions throughout the Holocene are limited in that they often rely on geographically distant proxy data which can result in issues such as regional temperature reconstruction inaccuracies. To counteract this reliance on spatially distant records we have used bacterial biomarkers, glycerol dialkyl glycerol tetraethers (GDGTs), recovered from Australian lake sediments, to produce paleotemperature records from mainland Australia. In this presentation, I will review the use and challenges of these GDGT-based palaeotemperature reconstructions for Australian settings with a particular focus on temperature change over the last two millennia and beyond at Blue Lake, South Australia.

Listen… Ruwe's Talking;
Water, Fire Connections on Ngarrindjeri Country.

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Australia is one of seventeen megadiverse countries in the world whilst also facing the existential threat of mass biodiversity loss. Despite the federal government's recent optimistic internal review on their progress towards successful ecological restoration. Significant concern exists regarding the inadequacy of well-intentioned commitments that, in practice, fail to address the accelerating rate at which biodiversity loss is progressing.

Conservation and restoration efforts in Australia typically rely on the National Vegetation Information System (NVIS), which utilises pre-1750 (i.e. pre-European) vegetation models as a benchmark. These models are based on biophysical, 'bottom-up' modelling and expert elicitation, but pertinently lack empirical validation and fail to account for the millennia of active Indigenous care for Country. This study aims to address such limitations by employing palaeoecology to provide a high-resolution record of the Teringie Wetlands, South Australia. The restoration of these Ramsar wetlands is of critical importance to Ngarrindjeri people. We analyse sub-fossilised pollen and charcoal from a wetland sediment core, to reconstruct long-term vegetation and fire dynamics at the site. We also applied loss on ignition (LOI) and ITRAX analyses to understand sediment and geochemical changes of the wetland.

Here, our 7,000-year record identifies shifts in vegetation, fire, limnology and geochemistry, particularly as a result of colonial river regulation and the suppression of Ngarrindjeri care for Country. By centring the philosophy of Yarluwar-Ruwe (Sea country), which recognises the land and waters as a single, living body, this study challenges de-humanised conservation paradigms. True ecological recovery of the Teringie Wetlands requires moving beyond modelled benchmarks to incorporating empirical palaeoecological evidence and Indigenous knowledges. This approach provides a robust foundation for revitalising the wetlands and honouring the enduring connection between the health of the Ruwe (Country) and the health of its people.

Neotoma and The Indo-Pacific Pollen Database – new features and initiatives.

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The Indo-Pacific Pollen Database (IPPD) is a constituent database in Neotoma, a popular online repository of palaeoecological data. The IPPD has undergone significant expansion in recent times, now representing hundreds of pollen records, both surface samples and ancient cores. At the same time, Neotoma has introduced several new features and initiatives to aid Indigenous Data Governance (IDGov) in the US. This is one of many global initiatives looking to improve communications between Indigenous groups and the palaeoecological community in recent years. It is hoped that the new features, such as expanding the site information in dataset DOIs to include their Indigenous lands, as well as re-introducing and improving data embargo features will aid end users in fully acknowledging and respecting IDGov. Here we will outline Neotoma's new features in this space as well as discuss their relevance to the Australia and the IPPD. We will also provide a full update on recent work on the database and future plans.

Holocene dryland river evolution in response to ENSO-driven hydrological change.

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Palaeochannels preserved on alluvial plains are valuable indicators of climate-driven hydrological change. Across the Murray-Darling Basin, such palaeochannels display shifts from larger Pleistocene, to smaller Holocene channels that define the modern landscape. In the Macquarie River Distributive Fluvial System (DFS), larger through-going palaeochannels contrast with the smaller modern river that declines in capacity, breaking down to form the Macquarie Marshes. The Holocene transition to modern fluvial conditions is marked by a precipitous decline in channel size and is not well understood. Crooked Creek palaeochannel is presented as an important, but missing, stage in this Holocene evolution. Using sediment analysis, mapping of channel morphology, and Optically Stimulated Luminescence (OSL) dating, this study reconstructed the palaleohydrology of Crooked Creek palaeochannel. 10 single-grain OSL ages place the channel between ~ 2 – 5 ka and possibly older, positioning it between the previously dated Mundadoo (~5–7 ka) and Marra (~2 ka) channels. Three phases of palaeochannel activity are proposed based on morphological differences, displaying a decrease in channel size and a progressive increase in the rate of longitudinal channel decline over time. These trends have been attributed to the strengthening of El Niño events in the mid-late Holocene, resulting in a drier catchment and reduced, more variable river flows. Additionally, this mid-late Holocene evolution is characterised by frequent avulsions to form an anastomosing system as well as multiple phases of wetland development. This suggests that channel stability and wetland dynamics are closely linked to variability in flow regimes, underscoring the sensitivity of dryland rivers to reduced and increasingly variable discharge.

Detecting the anthropogenic hand: A modelling approach to test fire management legacies in forest-grassland systems.

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Understanding anthropogenic fire's role in shaping vegetation dynamics through deep time is critical for reconstructing cultural pyroscapes, yet feasible methods are extremely limited. Palaeoenvironmental proxies reveal fire regime changes and vegetation responses but have limited capacity to uncover dynamics or specific precipitating factors. Process-based models can address this by isolating climate's role and determining which dimensions of human fire use – spatial patterns, seasonal timing, frequency – most strongly influenced vegetation transitions. Such insights into historical fire stewardship would inform sustainable wildfire management strategies today.

However, representing both fire types and quantifying their effects on diverse vegetation at resolutions aligned with human activity across deep time is exceptionally difficult. Generally, existing models are unsuitable for this intersection of scales and lack necessary representations of anthropogenic fire use. To simplify the problem, we restrict attention to forest-grassland systems – ecosystems likely shaped by long human occupation that support reduction to an effective two-state system. We focus on theoretical ecotonal boundaries between vegetation types, where stability determines whether mosaics persist or collapse. Within these bounds, we adapted an existing spatially-explicit model of fire-vegetation dynamics designed for millennial timescales.

Our model operates at fine spatial resolution with annual timesteps over multiple millennia, incorporating vegetation state transitions, sub-annual climate cycles, and realistic fire spread dynamics. We integrate fundamental representations of anthropogenic fire use: where fires are preferentially ignited, when fires burn, and how frequently ignitions occur. Through systematic sensitivity analysis across these dimensions and climate contexts, preliminary results reveal that anthropogenic fire's contribution to vegetation dynamics is highly context-dependent, shaped especially by moisture regimes. These results provide process-based understanding of mechanisms through which human fire use drives vegetation state transitions, revealing how Indigenous people could have shaped landscape mosaics through strategic fire management across deep time, offering a crucial tool for reconstructing cultural pyroscapes.

Lower-Birrarung Billabong Country: long-term ecological dynamics of a culturally constructed lowland floodplain.

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Identifying historical ecological baselines and understanding subsequent variability over appropriate timescales is vital for informing sustainable land-management and ecological restoration. The lower-Birrarung (Yarra River) billabongs, located in metropolitan Melbourne, are a series of lowland floodplain wetlands which have been culturally constructed and stewarded by Wurundjeri Woi Wurrung over millennia. This project utilises sedimentary archives from these billabongs (i.e. oxbow lakes) to reconstruct pre- and post-British Invasion ecosystem dynamics. We assess how vegetation, hydrology, and fire regimes have responded to shifts in land-management practices through time by utilising pollen, charcoal, grain size, and ITRAX XRF scanning. Our palaeoecological reconstruction supports Wurundjeri Woi Wurrung knowledge that Billabong Country was maintained and cared-for before British Invasion. We further identify post-invasion shifts associated with grazing, clearing, flow regulation, and urbanisation.

Co-designed with Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation (WWWCHAC), and Melbourne Water, the emerging reconstructions provide culturally grounded narratives of historical ecological change and long-term Care for Country practices. By comparing pre- and post-invasion ecological states in a culturally constructed floodplain system, this work demonstrates the value of billabong sediments for resolving colonial impacts on Country through Indigenous-led restoration, specifically through informing ongoing WWWCHAC Narrap Care for Country.

Tectonic and climatic forcing on landforms and sediments in the Cape Fold Mountains, South Africa.

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The Cape Fold Mountains in southwest South Africa have developed by tectonic uplift since the Permian, and there are complex relationships between different forcing factors and landscape geomorphic responses. Tectonic uplift and folding have resulted in distinctive structurally controlled ridge-valley systems that have asymmetric cross sections with vertical to overturned strata. Uplift also resulted in enhanced erosion, marked by the formation of footslope fans that are commonly demarcated by neotectonic fault systems. The Cape Fold Mountains also fall within a semiarid zone with a significant inland aridity gradient but with extreme flood events driven by heavy episodic rainfall. Floods result in high river erosion and transport though fault-controlled valleys. Geomorphic and sedimentary evidence from this region demonstrate the interplay between tectonic and climatic drivers. Long-term uplift led to superimposed drainage and phases of weathering and erosion that have provided sediment for mountain slopes (including colluvial fans) and river floodplains. Long-term changes in climate and groundwater through the Pleistocene and Holocene are marked by the formation of calcrete within the sediment stratigraphy. Short-term extreme events such as floods and neotectonic uplift associated with earthquakes are triggers of rapid geomorphic change in the region, marked by distinctive sediment layers on slopes and floodplains.

Finding coastal boulder deposits and their corresponding wave events in Tonga and Australia.

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Coastal boulders are long-lived signatures of high-energy storms and tsunamis found on rocky coastlines. Following our discovery of the world's largest cliff-top boulder in Tonga (Köhler et al., 2025), we found nine more boulders ranging from 20 to 300 tonnes on the island of Tongatapu as guided by Traditional Indigenous Knowledge and toponyms. By compiling a coastal boulder database for Tongatapu based on six studies since 2009, four boulder clusters were identified from four sides of the island. This compilation allowed us to infer the relative ages of the corresponding wave events from their distance-mass distributions and to identify at least 13 past storm or tsunami events spanning from at least 7000 BP (plus some boulders with unknown, perhaps older transport ages) to the recent 2022 volcanic tsunami.

In contrast to Tonga, studies of coastal boulders began earlier in Australia but have lost traction over the past 15 years. A review of the literature identified 33 studies of coastal boulders in Australia, with 12 papers published between 1989 and 2000, 19 in the following decade, and only two since 2010. Across these studies, 147 boulders have been reported (Fig. 1). The largest boulders weighing over 200 tonnes. We also mapped and measured 20 newly identified boulders in northern NSW, some of which (<10 tonnes) were transported and/or remobilised during modern storm events such as the 2016 East Coast Low, low-pressure systems in 2020, and TC Alfred in 2025. The next step in this research is to apply inverse and forward models to estimate flow velocities and interpret the types of past wave events that transported some of the larger boulders on the East Coast.

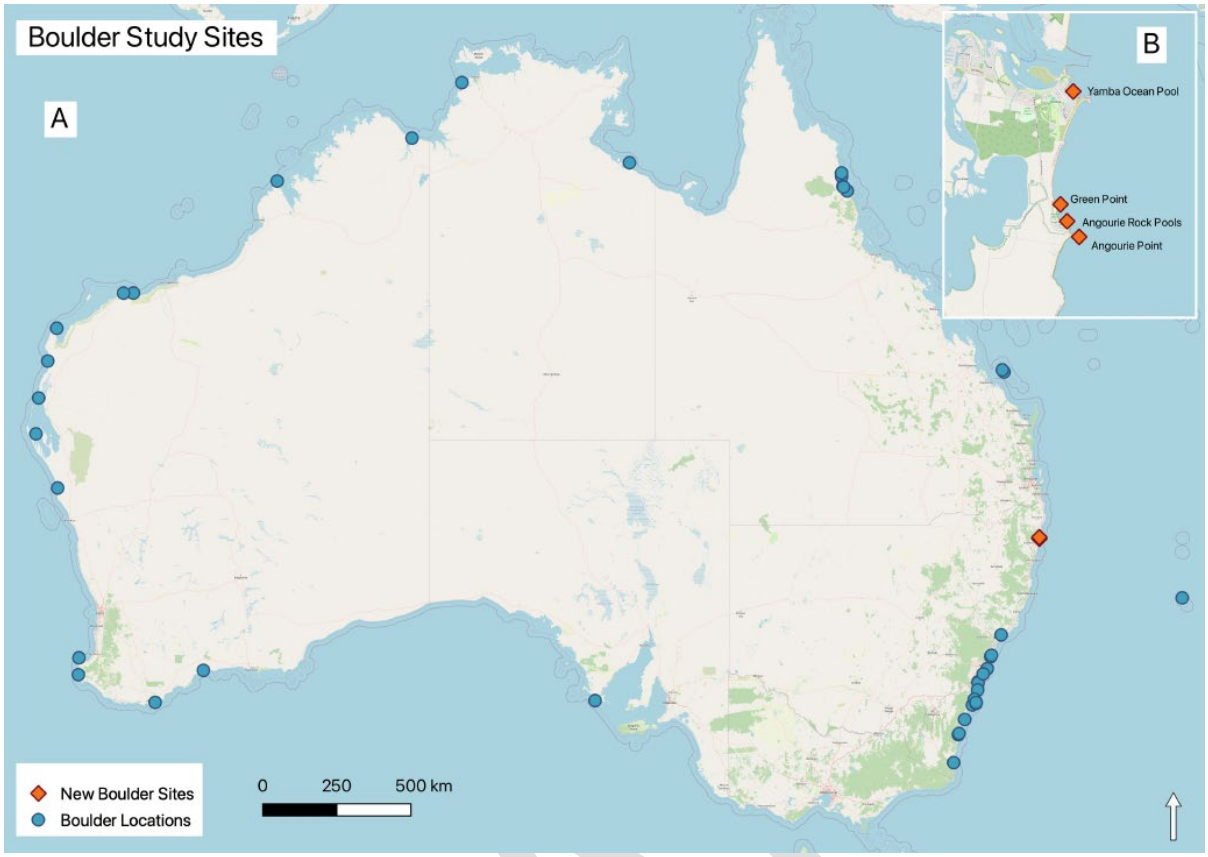

Fig. 1 Map of coastal boulders studied in Australia.

From source to sink: palaeoenvironmental reconstruction along the MIS 3 Rhine River with mammoth teeth.

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Mammoth teeth are increasingly studied with stable isotopes for palaeoenvironmental reconstructions during the past decades due to their frequent discoveries and capacity of recording sub-annual scale palaeoclimatic variations. In this study, eleven molar teeth of woolly mammoth (Mammuthus primigenius) coming from different locations along the Rhine River Catchment were studied for oxygen ($\delta^{18}O$), carbon ($\delta^{13}C$) and strontium ($^{87}Sr/^{86}Sr$) isotope compositions in their enamel carbonate. The samples were radiocarbon dated to several time windows during approximately 33-40 ka cal BP, and they were discovered in the fluvial sediments of multiple locations in Swiss Alps and Upper Rhine Graben, as well as dredged from the southern North Sea, covering from the approximate origin to the downstream delta of the Rhine Catchment during Marine Isotope Stage 3 (MIS 3).

We sequentially drilled the enamel of all specimens following the growth direction at millimetre resolution, and the obtained enamel powder was analyzed for $\delta^{18}O$ and $\delta^{13}C$ values using IRMS mass spectrometry. We then plotted time-series of $\delta^{18}O$ and $\delta^{13}C$ variations from all sample locations, and the high-resolution records were interpreted to reconstruct a variety of palaeoenvironmental properties, including river hydrology, precipitation, air temperature, vegetation composition and sub-seasonal scale climatic changes. These palaeoenvironmental properties were compared between different sample locations to investigate the spatial gradients in palaeoclimatic and palaeoecological conditions, as well as river hydrological balance, from south to north along the Rhine River. In addition, the $^{87}Sr/^{86}Sr$ ratios were also tested to analyse the mammoths' movements, and further determine whether they changed water sources during the time of tooth formation.

High resolution simulations of Australia's Quaternary climate.

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Australia is a warm and dry continent that has been inhabited for around 60 thousand years. Despite this lengthy period of habitation, but because of the nature of the Australian landscape, there are relatively few bioclimatic records of the continent's palaeoclimate, particularly from drier regions and that span the entire period of human occupation. Climate modelling presents an opportunity to fill this gap, but to date there have been few attempts to do so.

This work presents the first downscaled climate modelling simulations of Australia's Quaternary. The simulations were performed with the Weather Research and Forecasting (WRF) model, with boundary conditions taken from the Community Earth System Model (CESM). Three simulations were run for the Last Glacial Maximum (21 ka), the late Pleistocene (12 ka), and the mid-Holocene (6 ka), which were compared against a pre-industrial control simulation (1850 CE).

The high-resolution simulations quantify more precisely the changes in climate and identify the meteorological features that caused these changes. For example: changes in the monsoon extent, the incidence of tropical cyclones and east coast lows, and the Hadley circulation. Results from our simulations enhance our understanding of the palaeoclimate experienced by early Aboriginal populations and provides a valuable resource that may be used for the interpretation of archaeological discoveries.

Holocene fire and vegetation records from Mt Hugel, Cradle Mountain-Lake St Clair National Park, Lutruwita/Tasmania.

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Sphagnum peatlands are found across the Central Highlands of Tasmania and are threatened by climate change and fire. This study compared environmental archives from a Sphagnum peatland, buttongrass moorland, and lake near Mt Hugel in the Tasmanian Wilderness World Heritage Area (TWWHA). Palynological, charcoal and radiocarbon data reconstruct landscape evolution, fire regimes, and vegetation change throughout the Holocene. A 1.25m core from a striated Sphagnum peatland spans 1,500 cal yr BP, while cores from the buttongrass moorland (2.0m) and lake (0.9m) cover the last 8,000 cal yr BP. Radiocarbon dating of multiple fractions (macrofossils, macroscopic charcoal, fine fraction) from the peatland found macrofossils were consistently the youngest and most reliable. Macroscopic charcoal (>125 µm), loss on ignition and pollen analysis revealed similarities and differences between sites, with results suggesting increased fire activity occurred in the buttongrass moorland during the late Holocene. These findings will inform the ongoing management of threatened Sphagnum peatlands in the TWWHA by providing long-term records of disturbance and resilience in alpine ecosystems.

Reconstructing fire regime changes on Kangaroo Island, South Australia, using novel geochemical techniques

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Bushfires are becoming increasingly frequent in Australia as rising temperatures associated with climate change intensify periods of extreme heat and drought, raising fire risk. The 2019–2020 bushfire season, known as Black Summer, occurred during Australia's hottest and driest year on record and resulted in one of the most extensive fire events in the country's history. Kangaroo Island was among the most severely affected regions, with approximately half of its land area burned, leading to major ecological losses and highlighting the vulnerability of dense and biodiverse ecosystems.

Understanding how fire influences terrestrial ecosystems across decadal to millennial timescales is essential for developing effective conservation strategies, particularly as catastrophic fires are expected to increase in frequency and intensity. Sediment archives provide valuable records to reconstruct past fire regimes and assess interactions among climate variability, ecosystem dynamics, and human involvement in landscape management.

This study aims to reconstruct fire regime variability on Kangaroo Island (Figure 1) over approximately the last 10,000 years using a multi-proxy paleoenvironmental approach. Fire-related biomarkers, including pyrogenic sugars such as levoglucosan and polycyclic aromatic hydrocarbons (PAHs), will be used alongside traditional charcoal analyses to infer fire frequency, intensity, fuel types, and combustion conditions.

Sediment cores from wetland environments will be analysed for sedimentology, magnetic susceptibility, X-ray fluorescence (XRF), and radiocarbon dating to establish age-depth models. Fire reconstructions will integrate biomarker data charcoal counts and results will be interpreted alongside pollen and other proxies provided by collaborators. The study is expected to deliver a high-resolution Holocene reconstruction of fire regime variability and

to validate organic biomarkers and charcoal spectroscopy as reliable proxies for historical fire intensity and fuel types.

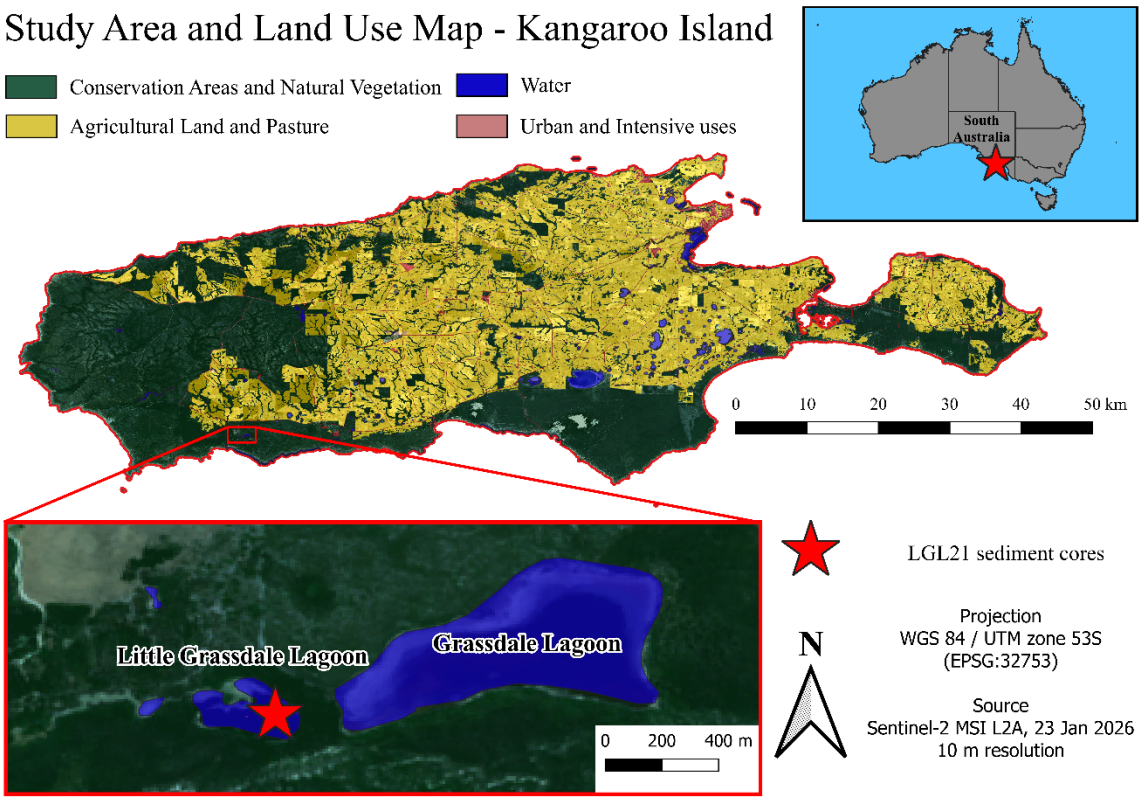

Figure 1: Study area and land-use map of Kangaroo Island, South Australia, showing major land-cover classes and the LGI21 sediment core sampling site (red star).

Fire Intensity Sensitivity of Stable Carbon Isotope Composition and Chemical Signature of Charcoal.

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Fire is an integral, ecological process of the Earth system, yet reconstructions of long-term fire dynamics from sedimentary charcoal records remain limited by the lack of robust proxies for fire intensity. Fossil charcoal accumulation is often used to infer fire occurrence and frequency, however, its potential to inform about combustion conditions has gained recent popularity. Experimental studies suggest that stable carbon isotopic composition ($\delta^{13}C$) and chemical structure of charcoal are sensitive to combustion temperature, leading to the development of maximum combustion temperature as an indicator of past fire conditions. However, charcoal transformation is not solely determined by temperature and may instead relate to a combination of combustion behaviour and fire energy dynamics (aka 'fire intensity'). This reflects the need to evaluate how chemical transformation and carbon signatures respond to varying fire intensity. This study experimentally produced modern charcoal analogues to understand how fire intensity alters the stable isotopic composition ($\delta^{13}C$) and chemical signature of pyrolysed organic matter. Modern charcoal analogues were produced under controlled laboratory conditions using open-flame burning apparatus to simulate a range of fire intensities, replicating vegetation fire conditions. Plant taxa common across eastern Australia were combusted at various fire intensities to generate comparative charcoals, with species selection maximised applicability for enhancing Quaternary palaeoecological charcoal records in this region. The modern charcoal was analysed using Fourier Transformed Infrared (FTIR) spectroscopy to characterise the chemical transformations associated with increasing intensity. The Modern Analogue Technique (MAT) was applied to FTIR spectra to assess the accuracy of inferring combustion intensities across burning apparatuses and taxa. Stable carbon isotope analyses were employed to map changes in $\delta^{13}C$ values across experimental conditions relative to source plant material. By integrating isotopic and FTIR spectrum data, this study aims to document the

chemical and carbon imprint of charcoal, enhancing the information derived from palaeofire research.

Reconstructing Holocene sea-level and palaeoenvironmental change from sedimentary archives using field and model-based approaches.

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Palaeo sea-level records play a critical role in capturing the variability of regional sea level (RSL) change by providing the long-term observational constraints that global sea level models urgently need. Southeastern Australia can provide records of Holocene relative sea level variability within sedimentary archives, enabling new insights into a tectonically stable far-field margin with exceptional potential to record Glacial Isostatic Adjustment (GIA) signals.

This research contributes to the gap in global palaeo sea-level databases by reconstructing RSL change from coastal sedimentary archives along the southeastern Australian margin. Raised beach deposits, often preserved in strandplains, provide an opportunity to reconstruct palaeo sea-level positions and other paleoclimatic signals across glacial-interglacial cycles. Chronological control may be established using Optically Stimulated Luminescence (OSL) and radiocarbon dating. These can be integrated with stratigraphic coring, sedimentological analysis, ground-penetrating radar (GPR) profiling, and airborne LiDAR-derived topographic mapping to understand the timing and nature of a Holocene highstand in southeastern Australia. This multi-method approach aims to produce high resolution palaeo shoreline elevations and depositional histories, from which new sea-level index points (SLIPs) can be derived. SLIPs provide dated, vertically constrained indicators of past sea-level position and directly address a critical data gap in southern hemisphere records.

Future research will collate this new field-derived RSL record for use alongside GIA modelling to explore ice sheet and Earth structure controls on sea-level change along this coastline. Such models can solve equations of gravitational, rotational, and deformational physics to generate predicted RSL curves for the study region. Mismatches between modelled and field-reconstructed sea levels using sedimentary archives can be used to critically examine model predictions, identify misfits, and refine global ice history. This approach has broader significance for understanding abrupt deglacial events such as Meltwater Pulse 1a, improving Earth system model calibration, and ultimately strengthening the physical basis of future sea-level projections.

A millennium of cool-season recharge variability at Yarrangobilly Caves: the Medieval Climate Anomaly as an analogue for modern drying under a positive Southern Annular Mode.

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Southern Australia has experienced a sustained decline in cool-season precipitation starting in the south-west in the 1970s, linked to a positive trend in the Southern Annular Mode (SAM). While instrumental records document this drying, its long-term context remains poorly constrained due to a scarcity of high-resolution paleoclimate archives for the Common Era. Here, we present two sub-decadally resolved speleothem $\delta^{18}O$ records from Yarrangobilly Caves (NSW, Australia), spanning ~300–1200 CE, supported by an extensive cave monitoring dataset and modern speleothem records. Recharge $\delta^{18}O$ variability at this site is dominated by changes in cool-season precipitation, the most effective season for transforming rainfall into infiltration. The isotopic composition of past recharge is directly measured from fossil dripwater trapped as fluid inclusions within the speleothem - a proxy that bypasses the isotopic fractionation effects inherent in carbonate $\delta^{18}O$, providing a direct measure of ancient recharge water.

Our speleothem proxy records show that periodic cool-season recharge, recurring on approximately centennial cycles, is a persistent feature prior to the Medieval Climate Anomaly (MCA: ~1000–1200 CE), but is largely absent during two key intervals: the MCA and the modern period. In both speleothems, the MCA is characterised by a gradual increase in $\delta^{18}O$ over~150-years, culminating in cessation of speleothem growth, potentially reflecting drying of epikarst reservoirs under sustained precipitation deficits. Both dry intervals correspond to positive SAM anomalies and are independently corroborated by the Law Dome sea-salt ice core record, which suggests reduced westerly influence over southeast Australia during the same two periods. Critically, our record directly demonstrates reduced effective cool-season recharge in southeast Australia during these intervals. These results suggest that anthropogenically driven cool-season precipitation deficits are comparable in magnitude to the most extreme dry interval identified in our paleoclimate record, with potential implications for water security across southern Australia.

Tracing variations in dust provenance using a high-resolution in-situ Sr isotope approach: a mid-Pleistocene flowstone record from the Flinders Ranges, South Australia.

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In marginal drylands, where aeolian sediment – and more specifically mineral dust – represents a dominant element in the environment, speleothems represent a scarce but valuable geochemical archive to reconstruct past dust sources and atmospheric circulation patterns. We present a novel application of high-resolution in-situ strontium isotope analysis to U-Th dated flowstone from Blue Wren Cave, Mt Chambers, northern Flinders Ranges, South Australia. The in-situ laser ablation approach enables unprecedented spatial resolution (0.01 mm sampling intervals, n=3,876 analyses) across flowstone transects.

U-Th dating constrains samples from ~528 ka to beyond dating range (296A) and 477-385 ka (296B), spanning MIS 13-11 and potentially older intervals. Flowstone $^{87}Sr/^{86}Sr$ values show substantial variability, ranging from 0.7075 to 0.7174 (median = 0.7119 ± 0.0005, 1SD), representing a large range relative to typical speleothem Sr isotope variations. These elevated values seem to suggest a high Sr contribution from radiogenic aeolian dust. However, the observed variations could reflect two fundamentally different processes with distinct climatic implications: (1) changes in dust provenance, with shifts between less radiogenic eastern sources and more radiogenic western sources, or (2) changes in the relative contribution of aeolian-derived Sr versus carbonate bedrock-derived Sr, representing variations in weathering intensity with a constant dust source. These hypotheses will be tested using complementary geochemical data, including trace elements and stable isotopes.

Re-framing Holocene Forest and Wetland Dynamics at Barrington Tops.

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The reconstruction of past climate and vegetation in eastern Australia between the Last Glacial Maximum (LGM) and present day is geographically focused on the low subtropical latitudes and far southern temperate latitudes. Understandings of past climate and vegetation change at the intersection of the subtropical and temperate latitudes (30–32°S) is lacking. The Barrington Tops Plateau is located at approximately 32°S and is situated above 1000m asl, positioning it as a site sensitive to environmental change. Here, we revisit LGM to Holocene forest and wetland vegetation dynamics at Barrington Tops by reanalysing legacy palaeoecological data with the addition of contemporary tools and comparing these results with recently collected high-resolution data from the same swamps. Four swamps have been cored as part of the Duumul Barray project – a traditional owner (Perry Aboriginal Corporation) led initiative that aims to nurture the growth of the endangered and culturally significant Bularr-gulga watuun (Diuris venosa) orchid, through cultural burning practice. Pollen, macro-charcoal and SedaDNA analysis will be used to provide new insights into the drivers of past vegetation change and a greater understanding of the role of fire in the past, present and future stewardship of the Barrington Tops National Park – Woromi Country.

Vegetation change over the Mid-Pleistocene Transition in Aotearoa-New Zealand: insights from a Hikurangi Subduction Margin record.

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In Aotearoa-New Zealand, continuous records of vegetation and climate change that extend beyond the last glacial-interglacial cycle are scarce, yet are essential for understanding how terrestrial ecosystems responded to global climate transitions. The Mid-Pleistocene Transition (MPT; 1250-700 ka) represents a major shift in Earth's climate, marked by a change from 41 kyr to 100 kyr glacial-interglacial cycles and associated reorganisations in the cryosphere, oceans, and atmosphere. However, comparatively little is known about how this climate transition impacted terrestrial vegetation.

Here we present a discontinuous 1.6 Ma pollen record from the upper 510 m of the turbidite-dominated International Ocean Discovery Program core U1520D, recovered from Hikurangi Subduction Margin east of the North Island of Aotearoa-New Zealand. This record captures time slices of vegetation change before, during, and after the MPT, providing new insights into how terrestrial ecosystems in Aotearoa-New Zealand responded to this global climate shift. Our results show that before and during the MPT, vegetation assemblages were cooler than the last two glacial-interglacial cycles (MIS 6-5 and MIS 2-1), and there was little variability between vegetation assemblages between glacial and interglacial periods. After ~0.5 Ma, vegetation shows more pronounced variability between cold and warm vegetation assemblages, reflecting the saw-tooth glacial-interglacial cycles characteristic of the late Pleistocene. Over the last 1.6 Ma, we observe a long-term increase in temperate podocarp-hardwood forests, indicating a warming trend that contrasts with the global cooling typically associated with the late Pleistocene and the MPT.

Our findings highlight how this globally significant transition reshaped terrestrial ecosystems in the southwest Pacific and demonstrate the potential of fine-grained, turbidite-dominated sedimentary records from active marine margins to serve as exceptional archives of past vegetation and climate change.

Groundwater recharge events since the early 20th century recorded via stalagmite trace elements and $\delta^{18}O$.

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Stalagmites are a well-developed archive for understanding hydroclimate, with dripwater measurements providing observations of potential groundwater recharge. Australian cave-monitoring hydrological datasets only expand back the last two decades, and longer-term groundwater bore monitoring is often impacted by extraction processes. Stalagmite records of groundwater recharge could therefore provide crucial insight into longer-term, baseline conditions.

Identifying past groundwater recharge events within stalagmites is critical for Australian dryland environments, where there is a need to understand the variability and role of climate drivers for sustainable groundwater management. As Australia's environment is largely water-limited, high soil moisture deficits must be exceeded before infiltration occurs. Stalagmites from these water-limited regions typically contain geochemical signatures that are highly responsive to effective infiltration (recharge) variability.

A stalagmite that grew on cave infrastructure (wire) since the early 20th century from Wombeyan Caves, SE Australia, provides an ideal candidate for reconstructing past groundwater recharge. Past recharge events are identified by analysing fluctuations in trace elements, $\delta^{18}O$, and carbonate fabric characteristics. The basal and upper ages of the stalagmite are constrained by the wire installation and the collection dates respectively, with ^{14}C measurements for additional chronological constraint. Preliminary trace element measurements show that the stalagmite (WMCW1) has simultaneous peaks in bedrock-associated elements (Sr, Ba, Mg) and soil-derived elements (Fe, Zn, Cu, K, Al, Pb), which reflect recharge events.

Due to the well-constrained chronology of WMCW1, trace element and $\delta^{18}O$ can be compared with the instrumental record to validate these as proxies for rainfall recharge of groundwater. These results will aid in further developing the current understanding of hydroclimate records in longer record stalagmites, in particular for SE Australia.

Peatlands of the Limestone Coast Region of Southeast South Australia – Insights from Palynology.

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Sediment from seven cores taken from two wetland sites located near Mount Gambier, South Australia underwent palynological analysis to investigate late Quaternary environmental change, particularly peat formation processes and impacts of European settlement on these highly significant wetland systems. The two wetland sites that were investigated were Ewens Pond (two cores collected within the wetland, one core collected in an adjacent paddock and one core collected in 1944) and Crescent Pond (one core from a never drained wetland, one from a remnant tea tree swamp area and one core from a degraded wetland in a nearby paddock). Palynomorphs, charcoal particles and Ascospores (dung fungus) were obtained from all of the sediment records, providing insight into vegetation change, fire history and presence of mammalian grazers for Ewens Pond and Crescent Pond. General findings include clear evidence of landscape modification (e.g. exotic taxa, wetland draining, land clearance, presence of livestock, and alterations in fire regimes) associated with European settlement of the Limestone Coast region, the importance of Tea Tree and Triglochin in peat formation at both wetland systems and some records potentially extending to the late Pleistocene, where different wetland taxa (Hornworts) may have dominated these systems, as well as providing insight into broader landscape change during the late Quaternary.

Spatio-Temporal Patterns of Sea Surface Temperature across Marine Isotope Stage 19.

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The interglacial Marine Isotope Stage 19 (MIS19, ~ 795 to 755 ka BP) provides the closest match of Earth's orbital parameters to the Holocene within the last 1 Ma. As such, this period represents a natural analogue for the Early Holocene before the influence of human activity influenced the global climate. Available estimates of MIS 19 global temperature rely on comparatively low-resolution stacks, which were compiled with the goal of creating multi-million-year temperature curves (e.g. Snyder 2016, Clark et al. 2024). Unlike for more recent interglacials, no dedicated MIS 19 surface temperature synthesis has been published to date. Our research aims to produce a benchmark dataset for MIS 19 model-data comparison and advance the systematic comparison of interglacial climate dynamics in the Mid- & Late Pleistocene. We compiled over 40 globally distributed sea surface temperature (SST) records with better than 6 ka resolution, covering the interval from Termination IX to the start of MIS 18. Individual age models were adjusted to a coherent chronology based on EPICA Dome C as primary alignment target, using the AICC2023 chronology. Proxy-based SST records were recalibrated using Bayesian methods to revise out-of-date temperature calibrations and to provide quantitative uncertainty estimates. Here, we present the resulting global and regional temperature curves to show the spatial evolution of SST across MIS 19. These temperature patterns, combined with the results of modelling studies, can offer insight into the dominant climate mechanisms which determine the properties of interglacials.

Paleoceanographic Changes in the Southwest Pacific Ocean Across the Mid-Pleistocene Transition.

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The deep oceans hold the largest reservoir of carbon on Earth, with the Pacific Ocean containing the largest amount. Glacial–interglacial CO_2 variations over the last 800 ka are thought to be driven by changes in deep-sea carbon storage and release, primarily exchanged by the Southern Ocean upwelling and exchanging carbon with the atmosphere. These shifts are recorded in benthic foraminiferal $\delta^{13}C$ from deep-sea cores, providing critical insights into the role of the deep-sea carbon cycle in Pleistocene climate variability.

Over 1.2–0.8 Ma, marine records show a major climate reorganisation known as the Mid-Pleistocene Transition (MPT). During this interval, Earth's climate shifted from relatively symmetric, low-amplitude 40-ky cycles to larger, more asymmetric 100-ky cycles. Although the mechanisms of the shift remain debated, one leading hypothesis links the MPT to enhanced glacial deep-sea carbon storage.

There are conflicting results for increased carbon storage in the deep oceans globally, with limited longer-term South Pacific studies assessing carbon storage and deep-water circulation over the last ~1 Ma. This study utilises the upper 27 m of the International Ocean Discovery Program (IODP) core U1526, from the Tūranganui Knoll seamount at the Hikurangi Subduction Margin, east of the North Island of New Zealand. We used benthic foraminiferal assemblages and stable isotopes to reconstruct changes in carbon cycling, oxygenation, and deep-water ventilation across the MPT.

During the last glacial period, anomalously low $\delta^{13}C$ values were observed at IODP cores U1520 and U1526. Here, we present new carbon measurements to understand the cause of these low $\delta^{13}C$ values, and determine if they are local signals or correlated to the regional South Pacific carbon storage.

Luminescence dating as a tool to understand Quaternary coastal landscape evolution in Australia.

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Luminescence dating (Thermoluminescence – TL and Optically Stimulated Luminescence – OSL) have been important tools supporting studies of Quaternary landscape evolution in Australia. Initially, testing of TL and OSL dating approaches against existing chronological data around the Australian coast provided foundational data and informed sampling strategies in a variety of depositional environments. Since then, studies have explored a wide variety of coastal landform types, including dunes, barriers, cheniers, aeolianite, tsunami and cyclone washover events, and subaqueous deltaic deposits and drowned barriers. This review focuses on the contribution of luminescence dating to Quaternary studies for three broad regions and coastal landform types: 1) transgressive dunes and the large sand islands of southeast Queensland (n. OSL and TL ages = 131), 2) prograded barriers comprising foredune ridges in temperate southeastern Australia (n. OSL and TL ages = 424), and 3) the uplifted coastal dune ranges of the Coorong Coastal Plain (n. OSL and TL ages = 64). Synthesising the luminescence chronology in these three key regions emphasises the different advantages and challenges encountered with luminescence dating, and the ways in which it can complement other geochronological methods. Furthermore, this review also affords the opportunity to contrast the luminescence properties and environmental dose rate characteristics of sediments across space and time. This review also provides guidance for future research utilising luminescence dating in coastal settings which ought to focus on refining the luminescence method, filling geographic gaps in our knowledge and investigating comparatively understudied landform types.

Radiometric age and palaeotemperature constraints on deglacial warming through Termination V.

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Glacial Termination V (TV; 430–420 ka) represents one of the most enigmatic deglaciations of the Quaternary Period, being characterised by a strong climate response to relatively weak orbital forcing and the persistence of large Northern Hemisphere ice sheets long after interglacial GHG concentrations had been attained. To understand why TV unfolded in this way, it is necessary to place changes occurring in different parts of the climate system onto a common precise chronology. Currently, the most robust age constraints for TV and the associated terminal Heinrich stadial come from a suite of remarkably well-dated Chinese speleothems. However, these records do not constrain climate evolution outside the East Asian Summer Monsoon domain over the later part of TV, precluding an assessment of the timing at which full interglacial conditions were reached. Moreover, this approach relies on assumptions about large-scale climate teleconnections that should ideally be tested using independently-dated climate records with a more direct link to the North Atlantic.

Here we present a speleothem record composed of multiple speleothems (stalagmites and a flowstone) precisely dated by the U–Th and U–Pb methods, as well as a rather unique subaqueous speleothem that is well-suited to Δ_{47} and Mg/Ca palaeothermometry. This new speleothem record provides precise constraints on the timing and magnitude of deglacial warming during TV in the mid-latitude North Atlantic realm. Aside from providing constraints on the timing at which interglacial temperatures were established, our new speleothem chronology also independently confirms synchronicity of the terminal Heinrich stadial

during TV (within age uncertainties) with the Weak Monsoon Interval identified in the Chinese speleothem record. This provides verification of the Chinese speleothem-based chronology for the early and middle phases of TV and reaffirms that TV was initiated under exceptionally weak (but rising) summer insolation at high Northern latitudes.

Palaeohydrology, fire and humans in south-eastern Australia: A biomarker and isotope perspective.

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Prolonged drought, declining precipitation and extreme heatwaves are increasing the risk of wildfires across Australia. Australia's fire regimes are linked to regional hydroclimatic conditions; however land management and fuel loads also play a significant role. Fire regimes evolve over decades to millennia, yet the datasets guiding contemporary fire policy extend back only decades. This temporal compression obscures the relative roles of climate variability and human land use in shaping fire activity, undermining efforts to anticipate and mitigate escalating fire risk. Current methods used to understand the drivers of past fire activity at decadal to millennial scales primarily rely on lake and wetland sediments through palaeoecology. While inferences can be made about the drivers of change from lake sediment proxy data, it is rarely possible to robustly distinguish between climatic and human influences. This limitation arises from two main constraints: a lack of appropriately scaled past climate data and a lack of reliable indicators of human activity.

We aim at addressing this limitation by developing appropriately scaled reconstructions of palaeohydrology, fire characteristics and human presence using innovative molecular proxies enabling the separation of climatic and anthropogenic drivers of fire through deep time, i.e. the past 30,000 years.

We present promising preliminary results that test these approaches on periods of abrupt climate change, such as the Late Glacial-Holocene transition in lake sediments from Tasmania and southwest Victoria. These are locations with a long history of Aboriginal occupation that also offer continuous archives of long-term landscape and climate history with existing palaeoecological data.

We applied the hydrogen isotope signature of n-alkanes (δD) to reconstruct local evapo(transpi)ration, suggesting hydrological changes in response to broad-scale climate shifts throughout the Late Glacial and Holocene. Polycyclic aromatic hydrocarbons were used as proxies for fire intensity and fuel to further clarify the occurrence of wildfires and/or cultural burning. Additionally, we tested the potential of faecal biomarkers (sterols) as a proxy for the local presence of humans and select animals. Altogether, our results demonstrate the potential for palaeoecological studies to employ molecular methods,

which have been rarely utilised to date, to better understand the interplay of hydroclimate and Care for Country across south-eastern Australia.

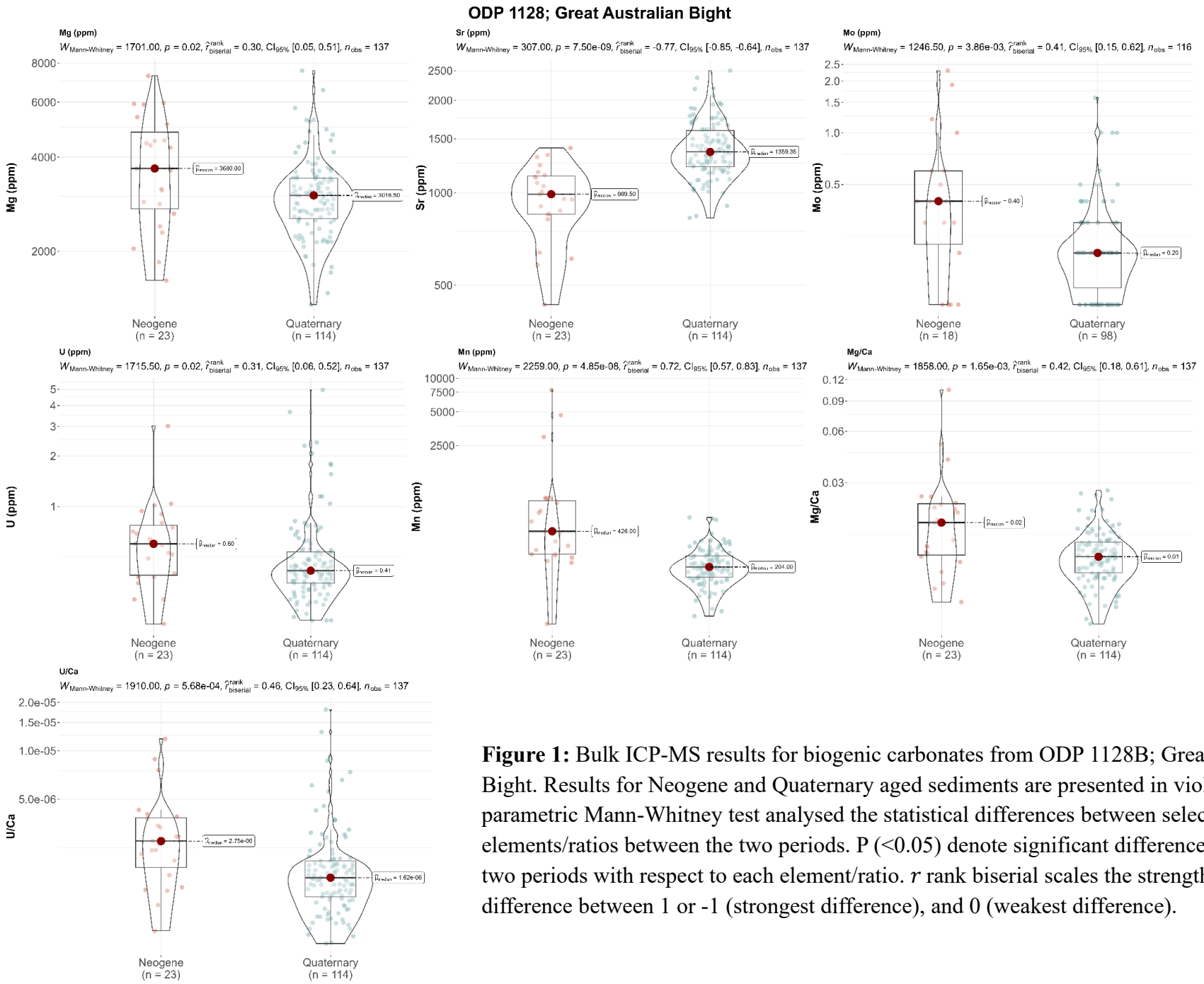

Figure 1: Bulk ICP-MS results for biogenic carbonates from ODP 1128B; Great Australian Bight. Results for Neogene and Quaternary aged sediments are presented in violin plots. A non-parametric Mann-Whitney test analysed the statistical differences between selected trace elements/ratios between the two periods. P (<0.05) denote significant differences between the two periods with respect to each element/ratio. *r* rank biserial scales the strength of the difference between 1 or -1 (strongest difference), and 0 (weakest difference).

Reconstructing Hydroclimate Variability in Western Victoria from a High-Resolution Record from Lake Bullen Merri with a New Diatom-Salinity Transfer Function.

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Sediments from permanent lakes are invaluable archives of late Quaternary climate variability. Concerns around the impact of climate change on Australian water resources and ecosystems increases the demand for a robust and quantitative understanding of past climate and hydrological variability. Diatom-salinity transfer functions applied to the sediments of deep, permanent lakes are a well-established palaeohydrological tool, albeit subject to uncertainties around the multiple influences on diatom communities and the validity of transfer functions beyond the calibration range. In this study, we developed a new salinity (measured as electrical conductivity; EC) transfer function using a large calibration dataset of 475 samples collected from 229 lake sampling sites across south-eastern Australia. A weighted averaging approach was used to develop the EC transfer function, which performed very well, with a high coefficient of determination and low prediction errors (jackknifed r^2 = 0.85; RMSEP = 0.39 log10 µS cm^{-1}).

This model was applied to a contiguous high-resolution diatom record from Lake Bullen Merri to infer hydroclimate variability over the last ~2500 years. Radiometric dating using ^{14}C, ^{210}Pb, plutonium concentration, and ^{137}Cs, was undertaken to establish a robust age–depth models. A 3.9 m composite sediment record was subsampled at 0.5 cm intervals to infer hydrological change at an average of ~5 years/sample. A total of 340 diatom microscope samples were prepared, and preliminary results indicate a series of prolonged periods of higher EC values reflecting decadal-centennial periods of reduced precipitation-evaporation. Dry phases were identified at ~500 BCE–300 CE, ~680–750 CE, ~870–980 CE, and ~1080–1300 CE, and ~1625 to present time. These results are interpreted in the context of existing paleoclimate records for the region, and potential climate drivers.

Late-Quaternary Australasian warm intervals evidenced by glacial-record contraction and gaps.

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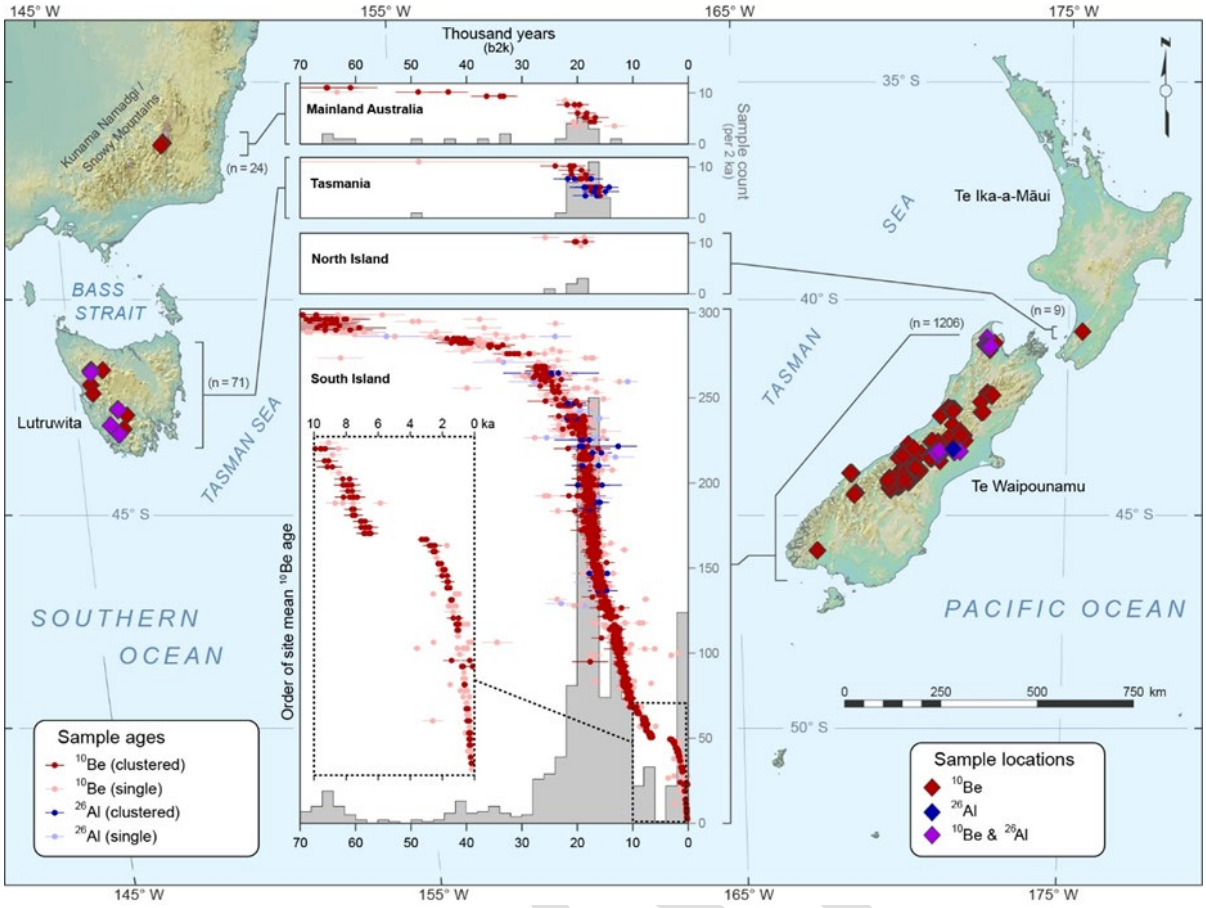
Interpretations of Southern Hemisphere Quaternary warming have traditionally focussed on continuous, and thus non-glacial, records. Proliferation of cosmogenic exposure dating is providing sufficiently detailed glacial chronologies to constrain warming of Australasia's temperate uplands, where alternative paleoenvironmental proxies may be limited. We evaluate glacial evidence of warming since Marine Isotope Stage 4 by synthesising multi-proxy glacier histories on both sides of Tasman Sea and recalculating 1307 glacial ^{10}Be and ^{26}Al-derived exposure ages from 291 published sites. Despite spatial-temporal variability in record detail, exposure-age population gaps suggest major warm periods whereas specific ice-recession sequences help identify precursory or lesser climate amelioration. The four regions of late-Quaternary glaciation differ notably in extent of glacial evidence and density of dated sites. Scant exposure ages in Australia's Snowy Mountains (24 samples) and New Zealand's North Island volcanic regions (6 samples) partially reflect spatially restricted glaciation (10s and 100s km^2, respectively) and complicates inferences of climate amelioration. South Island's widespread late-Quaternary glacial landscapes (>30,000 km^2) are far better constrained, enabling robust comparisons with detailed chronologies outside Australasia. Its recessional sequences indicate gradual deglaciation after 28 ka and widespread retreat 17-14.8 ka whereas hiatuses among its 1206 exposure ages suggest major warming ca.58-46 and 6-4 ka. Tasmania's limited published ^{10}Be and ^{26}Al ages (71 samples) and prevalence of small alpine glaciers among its Late Pleistocene ice extents (totalling ~1000 km^2) complicate identification of temporal gaps in glacial evidence. However, undated recessional sequences of valley glaciers fed by Central Plateau ice and coalescing cirque glaciers provide underutilised opportunities to constrain the timing and rate of post-glacial warming. Our review highlights future priorities: expanding Tasmanian glacial chronologies; systematic glacial geomorphic mapping using LiDAR, particularly of recessional moraine sequences; and expanded consideration of Middle to early Late Pleistocene glacial records preserved sporadically on South Island and extensively in Tasmania.


145° W
155° W
165° W
175° W
Thousand years
(b2k)
70 60 50 40 30 20 10 0
Mainland Australia
Tasmania
North Island
South Island
Sample count
(per 2 ka)
10 8 6 4 2 0 ka
Order of site mean ^{10}Be age
Kunama Namadgi / Snowy Mountains
(n = 24)
(n = 71)
BASS STRAIT
Lutruwita
TASMAN SEA
SOUTHERN OCEAN
35° S
40° S
45° S
50° S
SEA
Te Ika-a-Māui
(n = 9)
(n = 1206)
TASMAN
Te Waipounamu
PACIFIC OCEAN
0 250 500 750 km
Sample ages
^{10}Be (clustered)
^{10}Be (single)
^{26}Al (clustered)
^{26}Al (single)
Sample locations
^{10}Be
^{26}Al
^{10}Be & ^{26}Al

Constraining the timing of Neanderthals in Southern Iberia and evidence of marine resource consumption: Cueva de la Araña (Abrigo 3 & Cueva del Humo).

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Understanding the timing of Neanderthal habitation across southern Iberia is vital for debates about the persistence and demise of this species in regional refugia, and its adaptability to changing environments. However, resolving these issues is complicated by the limited availability of rigorous chronological frameworks for key Iberian sites. Here we present new luminescence ages for two sites from the Complejo del Humo (Cuevas de la Araña), an important yet understudied Middle Palaeolithic locality in southern Iberia, with the aim of revising the timeline of Neanderthal occupation. Our results indicate the last evidence of habitation during Marine Isotope Stage (MIS) 5, which is significantly earlier than previous radiocarbon chronologies suggest but broadly aligns with uncalibrated U/Th determinations for speleothems preserved at the site (Ramos Fernandez et al., 2012). These findings highlight the importance of adopting multiproxy chronological approaches in correlation with new archaeological interpretations to improve understanding of southern Iberian Neanderthal site dynamics, especially where previous chronologies have relied on sub-optimal radiocarbon pretreatment methods or sample types.

The revised chronology also reshapes the significance of the shell-matrix layers preserved at Abrigo 3, which record the collection and consumption of marine resources by Neanderthal populations during MIS 5. Such behaviours support the idea that the adaptive and cognitive abilities of Neanderthals were not fundamentally different from those of contemporaneous modern humans and reflected parallel strategies of subsistence and innovation.

Sedimentological and geochemical data further suggest that Abrigo 3 has a distinctly different infilling history compared to the neighbouring Cueva del Humo site. These two sites preserve different depositional environments: Abrigo 3 is influenced by marine conditions and subject to subsequent coastal erosion and reworking, while Cueva del Humo was shaped mainly by terrestrial clastic accumulation in a more sheltered karstic setting. These findings underscore the importance of considering site formation processes and geoarchaeological context when interpreting Neanderthal occupation dynamics.

Where There's Smoke, There's Stewardship: Elucidating 16,000 Years of Taungurung Fire Management in Northeast Victoria.

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Australian landscapes have undergone dramatic transformation since European colonisation. Evidence from southeast Australia demonstrates that woody fuel loads increased following the disruption of Aboriginal fire management, contributing to increased wildfire frequency and intensity. Aboriginal burning practices typically employ low-intensity fires that open vegetation structure, reduce fuel loads, create firebreaks, and sustain ecosystem diversity across varied landscape types. In contrast, contemporary fire management approaches often oscillate between complete fire exclusion and broad-scale prescribed burning, lacking the nuanced understanding of fuel dynamics and local-scale fire behaviour that characterise Aboriginal practices. Further, separating anthropogenic and climate influences on fire regimes is challenging.

This study presents the first application of stable polycyclic aromatic carbon (SPAC) by hydrogen pyrolysis to two sediment cores that span the past 16,000 years from Taungurung Country (northeast Victoria, Australia). We examine fire regimes across alpine and semi-alpine granite landscapes that are currently forested. The cores were extracted from geographically distinct but comparable topographic and geological settings, enabling assessment of long-term human-fire-vegetation-climate interactions. Integrating charcoal influx with SPAC-derived fire intensity allows differentiation of fire frequency from fire intensity. The records identify distinct fire regimes through time that are associated with different vegetation communities. SPAC analysis effectively distinguishes periods of low-intensity fires that are characteristic of Aboriginal fire use. Comparative analysis across both sites indicates landscape-scale consistency in pre-Invasion fire regimes. Our multi-proxy approach reveals how Taungurung care for Country practices created and maintained wildfire-resilient ecosystems across this region.

These findings contest the assumption that high-severity wildfire regimes represent natural baselines in forested alpine systems. Recognising this history is not symbolic; it materially alters how contemporary fire management baselines are defined under accelerating

climatic change. Understanding and integrating Indigenous knowledge systems is essential for effective conservation, offering practical solutions for contemporary environmental challenges whilst honouring millennia of Taungurung Care for Country practices.

Non-eucalypts as alternative ecosystem engineers during MIS 5 in northern Australian savannas.

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This study presents a high-resolution reconstruction of Marine Isotope Stage 5 (MIS 5; 129–71 ka BP) vegetation dynamics from Girraween Lagoon in northern Australia's Top End, highlighting the central role of non-eucalypt taxa in shaping savanna structure and function. The pollen record reveals that early–mid MIS 5 was characterised by intense monsoonal activity and widespread waterlogging, conditions that suppressed Eucalyptus/Corymbia yet facilitated the expansion of sclerophyll non-eucalypts. These woody groups formed diverse scrub-heath and mixed-forest mosaics and acted as functional analogues of eucalypts: they maintained flammable vegetation, supported grass–woody feedbacks, and prevented monsoonal forest from dominating despite favourable hydroclimate. Non-eucalypts were therefore pivotal in sustaining savanna processes during intervals when eucalypts were climatically disadvantaged.

These findings challenge the traditional savanna–rainforest binary by demonstrating multiple stable woody states, and they highlight the importance of non-eucalypts as alternative ecosystem engineers. Their capacity to replace eucalypts under extreme hydroclimate has key implications for forecasting savanna resilience under future environmental change.

Not a One-Size-Fits-All: Mercury Deposition Across Southern Hemisphere Sub-Antarctic Islands.

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Mercury (Hg) is a volatile toxic metal with strong atmospheric mobility, making its biogeochemical cycle highly sensitive to climate change. A key challenge is distinguishing natural climate-driven variability from anthropogenic impacts. This study examines how colonisation and climate change have shaped Hg contamination across the Australia–Pacific region. Previous work shows increasing Hg deposition in remote environments since the colonial era. Here, we apply a multi-proxy framework—combining Hg isotopes, geochemistry, and robust chronologies derived from radiocarbon, lead-210, and plutonium dating—to lake sediments from southern Australia and sub-Antarctic islands (Macquarie and Campbell). These records allow us to separate long-range transport, anthropogenic emissions, invasive animal disturbance, and climate drivers such as the southern hemisphere westerly winds. By integrating isotopic, geochemical, and age-model data, we quantify Hg sources and accumulation rates, providing new insights into Hg cycling in lacustrine ecosystems under changing climate conditions.

Depositional history of lunette dunes of western Victoria, south-east Australia.

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[4]School of Geography, University of Melbourne, Carlton, Australia;
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[7]Atmospheric Chemistry Group, Max Planck Institute for Chemistry, Mainz, Germany;
[8]Barengi Gadjin Land Council Aboriginal Corporation, Horsham, Australia;
[9]Eastern Maar Aboriginal Corporation, Warnambool, Australia;
[10]Gunditj Mirring Traditional Owners Aboriginal Corporation, Breakaway Creek, Australia.

Western Victoria hosts widespread moon-shaped dunes on the downwind, eastern shorelines of ephemeral lakes – so called lunettes – located across present-day semi-arid to temperate climates. The sediments within these aeolian deposits preserve valuable information about past environmental conditions which have long been recognised, whereby clay aggregates are deposited during lake-floor deflation and quartz sand indicates full lake phases. These lake phases have been linked to Late Quaternary climatic cycles, differences in moisture and aridity. The lunettes of the lower Wimmera catchment and surrounding Gariwerd/the Grampians Ranges, while widespread, remain poorly investigated for the information they provide about Quaternary environmental change.

Here we present on optically stimulated luminescence (OSL) dating and sediment characterisation of lunette dunes at Lakes Toolondo, Nekeeya and Bryans Swamp, located to the east, south and west of the Gariwerd/Grampians Ranges respectively, and lower Wimmera lunettes adjacent overflow lakes at Gurru/Lake Hindmarsh, Ngalpakatia/ Ngelpagutya/Lake Albacutya and in the Wyperfeld National Park. Our investigation provides new insights into the depositional history of lunettes and regional palaeoenvironmental implications spanning the last ~110 ka. We find evidence for major lunette deposition during the LGM and sediment accumulation under mostly full lake conditions around the Gariwerd/Grampians Ranges.

Investigating the impact of millennial scale climate events on southern Australia during the Last Glacial Period.

Sheridan, Louisa[1]; Fletcher, Michael-Shawn[1]; Drysdale, Russell[1]; Korasidis, Vera[1]; Gadd, Patricia[2]; Jacobsen, Geraldine[2]; Prochnow, Maximillian[1,3]; Zech, Roland[3]; Danius, Lisa[3]; Fallon, Stewart[4]; Lise-Pronovost, Agathe[1]; Treble, Pauline[2].

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The global impacts of millennial scale climate events are well researched, yet the scarcity of lengthy, high-resolution, and well-dated records from the Southern Hemisphere- particularly southern Australia- are limited. This constrains our understanding of the regional response to rapid climate events as well as interhemispheric leads & lags.

To address this knowledge gap, this multi-archive project produced three new southern Australian paleoclimatic datasets and improved the age-constraints and proxy resolution on one published paleoclimatic dataset.

A ~36,000-year-old sediment core was retrieved from Lake Bullen Merri (eastern Maar country, western Victoria). Bullen Merri is a large, endorheic maar lake that is sensitive to regional climatic, land use and precipitation/evaporation shifts. A suite of analyses were applied to this sediment core including radiocarbon dating, organic and inorganic geochemistry, palynology, charcoal and biomarker analysis (leaf wax n-alkanes and compound specific dD, fecal-derived sterols and polycyclic aromatic hydrocarbons). These results show significant hydroclimate, fire and human activity shifts throughout the past 36,000 years.

Additionally, speleothems from Mammoth Cave (Southwest Western Australia), Kubla Khan Cave (Tasmania, Australia) and Hollywood Cave (South Island, New Zealand) were analysed. We investigated the paleohydrology of these sites using stable isotope analysis ($\delta^{18}O$ and $\delta^{13}C$), trace element analysis and geochronology (U-Th dating). The datasets from Mammoth Cave (38-14ka) and Kubla Khan (75-23 ka) speleothems have demonstrated hydroclimate excursions associated with millennial climate events, likely due to the meridional displacement of the Southern Hemisphere Westerly Winds. Extensive U/Th dating of the Hollywood Cave speleothem (73-11ka) has altered the pre-existing, published age model, with implications for the current interpretation of millennial climate event timing in the southern mid-latitudes.

These results provide novel, well-dated and high-resolution evidence of the southern Australian response to millennial scale climate variability as well as the human-environment-climate relationship throughout the late Last Glacial Period.

Speleothem fluid inclusions record moisture variability in semi-arid southeast Australia during the last glacial period.

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Moisture-limited drylands are projected to become drier in southern Australia under the poleward displacement of the mid-latitude westerlies linked to Hadley Cell expansion. In contrast, southern Australian speleothems record intermittently high moisture availability during glacial periods, when episodic shifts in mid-latitude and tropical systems enhanced precipitation and cooler temperatures reduced atmospheric evaporation. The extent to which changing storm tracks and evaporative demand drove moisture availability remains unclear.

Here we present fluid inclusion results from a suite of speleothems formed during the last glacial period at Cliefden Caves (NSW), a semi-arid site sensitive to the shifting influences of mid-latitude and tropical storm tracks. Speleothem fluid inclusions preserve fossil drip water within calcite formed during speleothem growth, providing isotopic constraints on past meteoric water. By comparing the isotopic composition of fossil water and modern precipitation, we reconstruct changes in moisture source pathways during the last glacial period, strengthening constraints on the past balance between precipitation and evaporation in semi-arid southern Australia.

Sediment hiatuses in Holocene sedimentary records along with eastern Australian coastal margin: an obstacle to, and an opportunity for, quantitative climate inferences.

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Inferences of Holocene hydroclimate for the eastern and south-eastern Australian coastal margin have often concluded that during the "mid-Holocene" from 9,000 to 4,000 years BP the climate was wetter than in the subsequent 4,000 years. The precise nature of this purported transition (i.e. synchronous, time transgressive or variable) is difficult to determine due to a lack of dating resolution at the majority of sites. Proxies preserved in lake sediments (e.g. pollen, sediment geochemistry and a range of isotope data) are a primary source of this information.

Recent research has shown that three lakes on K'gari dried during the mid-Holocene (Tibby et al. 2025; J Quat Sci). This conclusion was drawn from hiatuses in sedimentation which indicate that the lakes dried entirely or shallowed to a depth that did not permit preservation of organic matter. This finding contrasts with conclusions drawn from other Holocene studies the region (e.g. Minjerribah or North Stradbroke Island) and beyond.

In this study we investigate the possibility that this drying event was, in fact, much more widespread. Examination of numerous Holocene records from a variety of sites on the eastern coastal margin suggests that we cannot reject the null hypothesis that hiatuses in sedimentation did not occur. In combination, these findings highlight a need to revisit commonly held assumptions about Australian Holocene climate and a need to develop much more robust sediment chronologies in order to test these ideas.

From Drip Water to Water Table: Calibrating Speleothem $\delta^{18}O$ as a Proxy for Rainfall Recharge to Groundwater.

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Speleothems are well-established archives of past hydroclimate yet translating their oxygen-isotope data into quantitative information about rainfall and groundwater recharge remains challenging. Speleothem formation is directly related to potential groundwater replenishment by rainfall recharge. The latter is increasingly critical to understand as climate change amplifies water scarcity and places greater pressure on aquifers and groundwater-dependent ecosystems. Speleothems offer a promising and under-utilised proxy for groundwater replenishment.

In this study, we combine cave drip-water monitoring and groundwater observations to calibrate the speleothem $\delta^{18}O$ response to rainfall recharge. We apply this calibration to a new, continuously grown 0–11 ka speleothem record from southwest Australia to reconstruct water-table variability through the Holocene. Our reconstruction indicates that sustained periods of rainfall recharge occurred during less than 70 % of the Holocene, underscoring the long-term vulnerability of groundwater resources in this region—particularly given the marked decline in water availability observed over the past ~50 years.

This new record provides a baseline for evaluating future groundwater stress and will also be used to identify the climatic drivers that promote effective recharge in southwest Australia.

Interglacial temperatures over the last 420,000 years in the eastern Mediterranean region: clumped isotope evidence from Lake Ohrid, North Macedonia/Albania.

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Variability in continental air temperature is a critical component of Earth's climate system. Quantitative palaeotemperature reconstructions are central to estimates of global climate sensitivity to changing atmospheric pCO_2. Furthermore, surface air temperature is a key driver of atmospheric circulation and the spatial distribution of precipitation, as well as the evaporation of surface water back to the atmosphere. Robust, quantitative estimates of continental palaeotemperatures are essential, yet this fundamental variable remains poorly quantified by past climate reconstructions.

The sediments of Lake Ohrid (North Macedonia, Albania) provide a unique resource to address the demand for long, quantitative and physically-grounded records of past temperature. Lake Ohrid is probably Europe's oldest continuous lake, with sediments that span the last 1,300 ka. The interglacial sediments of Lake Ohrid are rich in endogenic calcite, which precipitates in surface waters during the spring and summer seasons due to photosynthetic assimilation of aqueous CO_2. Fluctuations in the calcite concentration of the Lake Ohrid sediments clearly document the 20 glacial and interglacial periods since the formation of the lake.

Here, we report preliminary palaeotemperature estimates using the clumped isotope palaeothermometer, applied to Lake Ohrid carbonates. The data provide snapshots of interglacial summer temperatures during the last five interglacials (Marine Isotope Stages 11-1). The data are interpreted in the context of changing global drivers (sea level, orbital forcing, atmospheric pCO_2) as well as existing proxy data from Lake Ohrid and the surrounding region.

High-Resolution Chronology of Early Pleistocene glacial Terminations XVIII and XVII.

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During the Quaternary Period, Earth's climate oscillated about 50 times between glacial and interglacial states. The low-amplitude, 40-kyr pendulum of this sequence during the Early Pleistocene switched dramatically at around 1 million years ago – the Middle Pleistocene Transition (MPT) – when longer 100-kyr cycles became dominant. The cycle amplitude also increased at this time, and a more pronounced saw-tooth pattern to the cycles emerged. Several hypotheses have been proposed for the Early Pleistocene 40-kyr cycles, with recent work suggesting that insolation intensity in the Northern Hemisphere (NH) high latitudes, rather than the more typically presumed obliquity, triggered each termination. Notwithstanding this, determining the most important orbital parameter remains a problem due to uncertainties over the precise timing of these terminations. North Atlantic marine sediment records possess the best-preserved imprints of these terminations, but precise dating is lacking. Thus, there is a need to build paleoclimate proxy time series using precisely datable archives (such as speleothems) that preserve terminations and combine these series with ocean-core data to resolve phase comparisons with orbital/insolation metrics.

Our results from the Corchia cave speleothem, highlight the critical interactions between the $\delta^{18}O$ and $\delta^{13}C$ of the stalagmite and the U1385 planktic and benthic. A continuous decline in the $\delta^{18}O$ of the planktic between 1195 and 1190 ka identifies T-XVII although the concurrent decrease in speleothem $\delta^{18}O$ and $\delta^{13}C$ occurs about 15 kyr earlier. This highlights the chronological uncertainties associated with dating Early Pleistocene terminations, which makes it difficult to identify the insolation metrics responsible for their forcing. Radiometrically dated speleothem records will ultimately improve the ocean-core chronologies, and this study underscores the importance of these paleoclimate archives in resolving the timing and dynamics of these glacial-interglacial cycles.

Onset of continental-scale ice sheets in the Northern Hemisphere ~ MIS 100?

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Reconstructing Northern Hemisphere ice sheets is fundamental to resolving the coupled evolution of Quaternary sea level and climate. Yet, terrestrial records of Europe's earliest glaciations are fragmentary and difficult to align with more continuous marine archives. Here we present cosmogenic ^{26}Al–^{10}Be burial chronologies, geochemical, and detrital zircon U–Pb provenance constraints for key glacigenic successions across northwest and central Europe that challenge prevailing models for the timing and extent of the first Eurasian Ice Sheets (EIS).

Our results show that a continental-scale EIS was first established at $2.35\ ^{+0.41}_{-0.31}$ Ma and recurred throughout the Early and Middle Pleistocene, substantially predating the conventional onset of widespread lowland glaciation during MIS 12–16 (~ 425–675 ka). Ice flow through the Baltic corridor was active by ~ 1.7 Ma, sustaining extensive ice sheets that advanced across the North European Plain and likely eroded the headwaters of the Baltic River system; leading to its collapse by ~ 1.75–1.56 Ma. Increased freshwater flux to the North Atlantic during these intervals may have influenced overturning circulation and contributed to cyclical climate variability on orbital- and millennial-scales.

The timing of the first trans-Baltic EIS overlaps the Laurentide Ice Sheet maximum ($2.42\ ^{+0.14}_{-0.14}$ Ma), hinting at a potentially unified response to global cooling in the earliest Pleistocene. The overlap points to substantial ice volumes accumulating on the northern continents during the intensification of Northern Hemisphere glaciation; more than a million years prior to the Mid-Pleistocene Transition and within the apparent low-amplitude glacial cycles of the '41-kyr world'. This updated view calls for revision of long-standing European chronostratigraphic models and highlights a dynamic role for Eurasian glaciation in reorganizing continental drainage, modulating North Atlantic freshwater flux, and ultimately shaping the global climate system during a critical period of Late Cenozoic change.

Evaluating environmental change across Sahul during MIS 5: what proxy–model agreement and disagreement reveal about regional climate drivers.

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New Australasian palaeo-environmental data are improving our understanding of the climate during marine isotope stage 5 (MIS 5; 130–71 ka). The Southern Hemisphere exhibits regional variability and does not necessarily follow Northern Hemisphere climate. Global climate models of MIS 5 often disagree with Australasian proxy records and with each other. When, where, and how models fail can provide important information. Marine Isotope Stage 5 is a useful interval for exploring climate dynamics in Australasia because the period predates evidence of human landscape management across the region, which can confound interpretation of environmental change during the last glacial cycle. Its sub-stage oscillations (5e–5a) also provide a sequence of well-characterised forcing conditions, with MIS 5e considered roughly analogous to present-day climate. We compared terrestrial and marine proxy records across seven regions of Australasia from Sunda–Wallacea to southern Australia. We also evaluated regional time series from two structurally different palaeoclimate models (LOVECLIM and bias-corrected HadCM3). We standardised all records and interpolated them to common time steps. We applied correlation, spectral, and change-point methods to examine lead–lag relationships between proxies and models, evaluate the sensitivity of different records to chronological assumptions, and test whether proxy and model series respond to the same forcing periodicities. Analyses explore several questions: (i) whether a tropical–temperate moisture seesaw operated during MIS 5 and, if so, how its expression varied across sub-stages; (ii) whether the two models respond to different aspects of insolation forcing, and what this implies for the phasing of monsoon precipitation; and (iii) whether apparent lags between proxy records and model outputs reflect response times, proxy sensitivity, or artefacts of age models. We examine these questions and discuss how structured proxy–model comparison can help constrain the drivers of environmental change in a region where MIS 5 records are rare and conventional model evaluation has had limited success.

Restoring the lost Ericaceae of Botany Bay's scrublands through a palaeoecological approach in southeastern Sydney, Australia.

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With anthropogenic environmental change accelerating, incorporating long-term perspectives into ecological restoration is essential. Paleoecological evidence increasingly indicates that many perceived "natural" landscapes under current conservation regimes are, in fact, cultural or modern systems. However, the application of long-term data to restoration is often hindered by limited taxonomic resolution achievable in paleoecological reconstructions, which frequently classify fossil pollen to the familial, multi-generic, or generic level. This leaves practitioners with numerous potential species to consider, impeding species- or community-specific restoration. We use a case study focusing on southeastern Sydney's heath-wetland complex to test how a targeted palynological approach combined with local and practitioner knowledge can increase the taxonomic resolution of paleoecological data and support its use in restoration. We use detailed reference pollen analysis and morphological comparison to improve the identification of subfossil Ericaceae pollen from the familial to the species-level, and apply the revised pollen taxonomy to existing paleoecological records. We identify two key Ericaceae species—Sprengelia incarnata and Monotoca scoparia—that played a significant role in southeastern Sydney's Indigenous and early- to mid-nineteenth century heath-wetland complex. Despite the overwhelming abundance of these species in subfossil archives, they are under-represented or missing in contemporary listings of Endangered Ecological Communities conserved as remnants of the original landscape by State and Federal laws. Our findings offer practical insights for restoring these communities and demonstrate the potential of applying this technical approach to meaningfully inform restoration efforts globally.

Intertidal peats and fossil forests of the Recherche Archipelago: a multi-proxy record of early–mid Holocene sea-level rise.

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Intertidal peat deposits and in situ fossil stumps preserved along the coast of the Recherche Archipelago provide a rare archive of coastal landscape change during the early–mid Holocene in southwestern Australia. This presentation outlines new chronological, pollen and microfossil results from multiple sites across the Recherche region, including the widely publicised Wharton Bay locality.

Together, these records show that extensive low-lying wetlands and coastal forests once occupied areas that are now intertidal. Pollen assemblages indicate vegetation dominated by shrub- and sedge-rich kwongan, while marine microfossils record changing hydrological conditions and increasing marine influence through time. Radiocarbon chronologies demonstrate that peat accumulation occurred prior to, and during, the final stages of post-glacial sea-level rise and the mid-Holocene highstand (~5.5 ka), after which many of these landscapes were drowned and buried by transgressive coastal sands. Evidence for repeated burning highlights the long-term role of fire in shaping these ecosystems.

These drowned wetlands and forests have important cultural significance. They represent landscapes that would have been available to Aboriginal peoples prior to marine inundation, providing insight into how coastal environments and resources changed as sea level rose. The fossil peat and stump records therefore contribute to broader discussions of past coastal occupation, environmental change and the long-term relationships between people and Country in the Recherche region.

This talk provides an overview of the emerging multi-proxy framework for reconstructing coastal evolution in the region and outlines future research directions aimed at building longer and more detailed records of environmental and cultural landscape change.

Changes in onset and withdrawal drive Asian Monsoon trends over the Common Era.

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Changes in the Asian monsoon onset and withdrawal are crucial for agricultural planning, and for water resource and disaster management. Past changes in monsoon duration provide valuable insights into mechanisms controlling monsoon variability and can help inform on monsoon onset and withdrawal timing under different climate change scenarios. Yet, reconstructions of past changes in monsoon duration are sparce, leaving our understanding of drivers and impacts on the hydrological cycle uncertain. We present a proxy-based large-scale synthesis of the Asian monsoon over the Common Era, addressing changes in monsoon duration. Over the past 1000 years, speleothem $d^{18}O$ from the three subregions (East, South, and Southeast Asia) suggest that the monsoon withdrawal began earlier, shortening the monsoon season in South and Southeast Asia. In East Asia, half of the records used indicate an increase in monsoon duration over the last millennium, while the other half suggests monsoon shortening. Combining our proxy-based reconstructions with Community Earth System Model (CESM) Last Millennium Ensemble Project simulations, we find that changes in monsoon duration are linked to the transit time of the rain belt, which differs by region. In South and Southeast Asia, the monsoon duration is primarily dictated by the monsoon withdrawal rather than onset timing. In contrast, the East Asian summer monsoon can be influenced by either depending on site-specific rainfall timing. We leverage these insights for monsoon projections and find that under high-emission scenarios the monsoon season will likely extend, with an earlier onset and later withdrawal. These findings can be incorporated into adaptation strategies that could ultimately help improve water resource management and food security.

POSTERS

Fire Regime Shifts in the Blue Mountains, NSW, During the Twentieth Century: Insights from Charcoal Records in Temperate Highland Peat Swamps

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Concern over the 2019–2020 Australian *Black Summer* bushfires and other recent wildfire events globally centres on whether they represent a shift towards a more extreme fire regime characterised by greater frequency, severity, intensity, or area burned. In Australia, however, instrumental climate and fire records are too short to resolve whether recent extremes are unprecedented in a longer-term context. This study addresses that problem by reconstructing Twentieth- and Twenty-first-century fire-regime variability in the Upper Blue Mountains, New South Wales, using high-resolution radiocarbon chronologies, charcoal accumulation records from Temperate Highland Peat Swamps on Sandstone (THPSS), and Raman spectroscopy of sedimentary charcoal. Charcoal accumulation rates were used to infer fire activity and variation in burned area or fire extent, while Raman spectroscopy was calibrated experimentally using multiple *Eucalyptus* taxa exposed to controlled heat fluxes of 20–50 kW m^{-2}. Among the Raman metrics tested, the area ratio A_D/A_G showed the strongest relationship with applied energy, whereas other parameters displayed weaker, non-linear, or convergent responses at higher heat fluxes, highlighting limitations in using Raman metrics alone as direct indicators of wildfire intensity. The charcoal record indicates that fire activity changed through the Twentieth century. Composite CHARa and CHARno series show generally low charcoal accumulation during c. 1900–1935, episodic peaks between about 1940 and 1975, and a marked shift to higher variability and larger peak magnitudes from the late 1980s onward. The largest composite peaks exceeded ~350–400 $mm^2\ cm^{-2}\ yr^{-1}$ in CHARa and coincided with charcoal counts >~2000 no. $cm^{-2}\ yr^{-1}$. By contrast, Raman-derived intensity trends followed distinct cyclic or stochastic structure and did not show a persistent monotonic increase. Overall, the results suggest that recent fire-regime change in the Upper Blue Mountains is expressed more clearly as greater variability and extent of charcoal-producing fire activity than as a persistent increase in fire intensity.

Holocene and Last Interglacial sea-level highstand records from Cook Islands speleothems.

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In the South Pacific maritime continent, there is increasing concern about the impact of sea-level rise on communities and their very existence. Accurate sea-level reconstructions for the Holocene and the Last Interglacial (129–116 ka BP) are needed to assess the role of eustatic versus relative sea level changes and test predictive models for single islands and archipelagos. The coastal caves in the Cook Islands archipelago are excellent sites to investigate local and eustatic sea-level fluctuations as they host abundant Holocene and Last Interglacial speleothems.

Here we present preliminary results from radiometrically dated stalagmites and phreatic overgrowths on speleothems (POS) from caves in Atiu (Pouatea, Nurau and Vai Akaruru) and Mangaia (Ana Tuatini and Ana Touropuru) investigated through stable isotopes, synchrotron-radiation XRF mapping, optical and fluorescence microscopy.

The caves are characterised by multi-level galleries that develop between the present-day groundwater level (GWL) and the top of the “makatea” (raised reef) at about 50 m a.s.l. and are connected to the sea via submerged galleries. This offers the opportunity to investigate in detail the Holocene GWL, local sea-level as well as infiltration fluctuations.

Holocene POS and submerged speleothems have been found up to 1.5 m above the present-day GWL. Their U-Th ages span the period 3.5 to 7.0 ka BP, in agreement with the Holocene sea-level highstand documented in the equatorial Pacific. During the same time interval, stalagmites located a few meters above the present-day GWL display fading organic lamination, thin micro-clay layers and anomalously high $\delta^{13}C$ values suggesting periodic submersion by the rising GWL within the cave.

On the other hand, the Last Interglacial highstand caused more dramatic modifications inside the caves, as documented by systematic dissolution of speleothems and deposition of clay layers as well as Fe-Mn crusts within the stalagmites.

A deep time phytolith record from Lake Yamma Yamma in arid Australia.

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POSTER

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Deep-time terrestrial vegetation records from Australia's arid interior are exceptionally rare. Existing long-term archives are largely restricted to the northern tropics and temperate southeast, reflecting the uneven preservation of organic plant remains (e.g. pollen and macrofossils) across the continent. Vegetation records from the arid interior are scarce, and none extend beyond the last ~100 ka. Consequently, the long-term responses of Australia's desert landscapes to repeated Quaternary climate forcing remain unresolved, representing a major gap in Southern Hemisphere palaeoecology.

The sedimentary archive from Lake Yamma Yamma, located within the Channel Country of southwestern Queensland in the Kati Thanda–Lake Eyre Basin, provides a rare opportunity to address this gap. Exploration drilling in the 1960s recovered a 100 m sediment core characterised by thick accumulations of lacustrine muds and evaporites. More recently, a 5 m test core recovered in 2024 provides a modern sequence for evaluating proxy preservation and stratigraphic consistency. Sedimentation rate estimates suggest that the sequence may extend into the mid–late Quaternary (>600 ka), potentially representing one of the longest continental sediment archives yet identified in arid Australia.

Here we introduce the first phytolith assessment of the Lake Yamma Yamma sequence, based on a paired analysis of the 100 m legacy core and the 5 m test core. Phytoliths (silica microfossils formed within plant tissues) are highly resistant to oxidation and degradation, making them particularly well suited to long-term preservation in arid-zone sediments. Preliminary observations indicate excellent phytolith preservation throughout the lower half of the legacy core, further highlighting the potential of this archive for deep-time palaeoenvironmental reconstruction.

Applied to this potentially >600 kyr sequence, phytoliths provide an opportunity to generate Australia's first deep-time vegetation record from the arid interior, advancing our capacity to understand long-term ecosystem and climate dynamics on the continent.

Tracking Arctic marine ecosystem change into the Last Interglacial in the eastern Fram Strait: a sedimentary ancient metagenomic record.

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The Arctic is highly sensitive to climate change. Presently, this region is experiencing anthropogenic warming at a rate four times the global average. Climate models predict with high confidence that we will experience at least one sea ice free summer in the Arctic by 2050. The most recent time the Arctic was seasonally ice free is thought to have been the Last Interglacial (Marine Isotope Stage 5e, between 116 and 128 thousand years ago), when global temperatures were up to 2 °C warmer than pre-industrial averages. Here, we present an ancient metagenomic record of Arctic marine ecosystem change capturing the transition into and out of the Last Interglacial from a region with typically poor diatom preservation. Our record comes from core material collected at Site U1621 on International Ocean Discovery Program Expedition 403. The site targeted the Bellsund Drift, a sedimentary depocenter in the eastern Fram Strait with expanded interglacial sequences shaped by the path of the West Spitsbergen Current, the main source of heat into the high Arctic. Our results show a clear shift from a diverse phytoplankton community characterised by cold and sea ice-associated diatom taxa during the Marine Isotope Stage 6 glacial to increasing dominance of the coccolithophore Gephyrocapsa huxleyi into Marine Isotope Stage 5e. This shift is likely related to the increasing influence of warm North Atlantic Water in the eastern Fram Strait. Our record also captures some of the more subtle environmental variability within the subsequent substages of Marine Isotope Stage 5. We also documented ecological changes in the prokaryotic community and at higher trophic levels, including detection of

codfish and marine mammals during the interglacial. Our results have relevance as an example for understanding how Arctic marine ecosystems respond to a transition from sea ice cover to open ocean, a change occurring in the higher Arctic Ocean today.

A high-resolution 4000-year hydroclimate reconstruction from Lake Purrumbete, southeastern Australia.

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Southeastern Australia has several high-resolution hydroclimate records, yet important uncertainties remain regarding regional variability and the drivers of extreme events such as droughts and floods. Here we present a new multi-proxy hydroclimate reconstruction spanning the last 4000 years from Lake Purrumbete, a maar lake in Victoria, Australia. A sediment core was retrieved from the lake centre and dated using radiocarbon on pollen, ^{210}Pb, and $^{239+240}$Pu, yielding a robust chronology with sub-decadal resolution across 300 samples. The organic fraction of the sediment is dominated by aquatic cellulose, confirmed by stable carbon isotopes (δ^{13}C) and Total Organic Carbon/Total Nitrogen ratios. Oxygen (δ^{18}O) isotope ratios of aquatic cellulose are analysed alongside bulk sediment carbon and nitrogen isotopes and X-ray fluorescence core scanning data to investigate past hydroclimate variability.

Preliminary results indicate variability in hydroclimate conditions over the late Holocene, including intervals characterised by shifts in isotopic composition and elemental ratios consistent with changes in lake water balance and catchment inputs. These patterns are evaluated in the context of existing regional paleoclimate records to assess the extent to which they reflect broader climatic trends in southeastern Australia.

In addition, recent sediment geochemistry is examined to explore the potential influence of European land-use change, although chronological refinement of this interval is ongoing.

This study highlights the potential of maar lake sediment archives to resolve hydroclimate variability at high temporal resolution and contributes new data to ongoing efforts to better understand late Holocene climate dynamics in southeastern Australia.

Exploring paleoenvironmental dynamics and sediment supply using OSL on the Weeli Wolli alluvial fan, Pilbara.

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Reconstructing paleoclimate in Northwest Australia remains challenging due to scarce organic material, extensive bioturbation, and complex sediment reworking across the Pilbara. Despite these limitations, the Fortescue Marsh, an ecologically significant wetland within the Upper Fortescue catchment, provides one of the region's most informative sedimentary archives. Previous studies have identified Holocene hydroclimatic variability, including alternating wet–dry phases, shifts in groundwater chemistry, and changes in carbonate isotope signatures. However, chronological uncertainty and limited preservation of suitable materials continue to constrain regional interpretations.

Recent work highlights the value of integrating multiple archives and approaches, including rock varnish geochemistry, climate modelling, and sedimentological records. While modelling studies differ on the extent of moisture balance changes during the Last Glacial Maximum (LGM), local sediment archives from NW Australia suggest reduced wet-season intensity between MIS 4 and the LGM, followed by increasingly variable conditions and a marked intensification of Indo-Australian Summer Monsoon activity during the early to mid-Holocene. These findings underscore the importance of site-specific sediment records for interpreting environmental change in Australia's arid–semi-arid transition zone.

This study focuses on the Weeli Wolli alluvial fan system and the fringe of the Fortescue Marshes, part of a large accretionary fan complex influenced by iron-rich lithologies and limited quartz availability. Using new optically stimulated luminescence (OSL) dating of alluvial and marsh sediments, we evaluate the extent to which post-LGM environmental variations represent transient events rather than long-term hydroclimatic trends. We further assess the timing of sediment export from the upper Fortescue catchment to the coastal shelf, providing new insights into when the Weeli Wolli fan functioned as an active, connected hydrological system. Together, these results refine the paleoenvironmental history of the Pilbara and demonstrate the critical role of local sediment archives in constraining broader climatic interpretations.

Australian Biogenic Carbonates: A Paleothermometer?

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POSTER

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The marine biogenic carbonate record is an exceptional but underutilised resource for paleoenvironmental interpretation. Sea water temperature controlled by latitudinal isotherms distribute biogenic carbonate factories into two, globally prominent depositional realms – warm/tropical/photozoan and cool/temperate/heterozoan. However, the behaviour of many trace elements between these depositional realms and their response to past climate change is poorly understood. Whole-rock (ICP-MS) and in-situ (SEM, LA ICP-MS) analysis techniques effectively characterise biogenic carbonates from the North West Shelf and Great Australian Bight of Australia with respect to their textural and geochemical composition. We propose several potential temperature proxies in deep pelagic carbonate sediment that assist in discriminating between warm and cool water depositional realms. We demonstrate their potential implications for tracking first order climate change between the Coolhouse Neogene (23.03 – 2.58 Ma) and Icehouse Quaternary (2.58 Ma – present) (Figure 1). This project adds to a growing database of high-resolution geochemistry for biogenic carbonates deposited off Australia's continental shelf. In-situ analysis of biogenic carbonate sediments has the potential to mark a step change in understanding localised trace element incorporation, which is otherwise lost in whole-rock technique

Reviewing the potential of using magnetic susceptibility to identify past wildfires in Australia.

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POSTER

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Fully understanding the causes and frequency of wildfires has never been more important than it is today, with potentially thousands of lives at risk from wildfire smoke in Australia alone. Until now wildfire frequency in Australia has been estimated based solely on observed fire events, records that barely cover the last century. This coverage is severely inadequate for a reliable estimation of wildfire frequency. Here it is suggested that records of magnetic susceptibility may help extend the wildfire records used, which will significantly increase the confidence level of estimated wildfire frequency. With Australian soils being rich in iron, the main factor limiting the use of magnetic susceptibility appears to be rainfall. Additionally, the magnetic susceptibility records of several sites may respond more to local hydrology or organic matter content than to wildfires, possibly due to insufficient heating of the soil. A comprehensive field study is thereby suggested, which will determine which site characteristics have the most significant influence on magnetic susceptibility records in Australia. This will enable more detailed studies to be conducted and will extend Australia's fire records.

Geomorphology and Holocene Environmental Change on Niuatoputapu, Tonga.

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POSTER

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Niuatoputapu presents an unusual geomorphic setting: unlike most Tongan islands, which are either volcanic or carbonate in origin, it combines both, featuring a volcanic island core surrounded by an extensive uplifted carbonate platform. This study reconstructs the island's geomorphological evolution and Holocene landscape development, integrating high-resolution LiDAR-derived topography with legacy datasets, sediment cores, and geochemical analyses. A revised geomorphological map is produced, significantly improving spatial accuracy and providing a framework for interpreting sediment distribution and inundation processes.

Geomorphological mapping reveals a multi-stage evolution beginning with volcanic island formation (~1.6–2.1 Ma), followed by Pleistocene reef accretion that developed a broad carbonate platform (~130–115 ka) potentially linking Niuatoputapu with nearby Tafahi. Subsequent phases of uplift, driven by volcanic loading or than regional tectonics, raised former reef flats and lagoonal environments and facilitated lateral island expansion through the formation of beach ridges and sand islets. These uplift pulses produced distinct geomorphic surfaces, including a Pleistocene terrace and younger Holocene strandline systems (<5000 a).

Holocene landscape development is further constrained through sedimentological analyses, including grain size distribution and X-ray fluorescence (XRF), alongside ongoing radiometric dating of foraminifera, mollusc shells, and corals through ANSTO and CHRONOS radiocarbon facilities. These datasets indicate a complex history of reef growth, exposure, erosion, and episodic sediment reworking. Progressive uplift led to the emergence and isolation of former lagoon environments, with sedimentation increasingly restricted to high-energy overwash events such as tsunamis.

The integration of geomorphological mapping and sedimentary records highlights the strong coupling between island morphology, sediment pathways, and hazard exposure. In particular, low-lying former lagoonal areas now act as key archives for extreme wave events, including the 2009 tsunami. This study also demonstrates a transferable workflow for enhancing legacy spatial datasets using modern remote sensing, offering broader applications for geomorphic and hazard research in data-limited island environments.

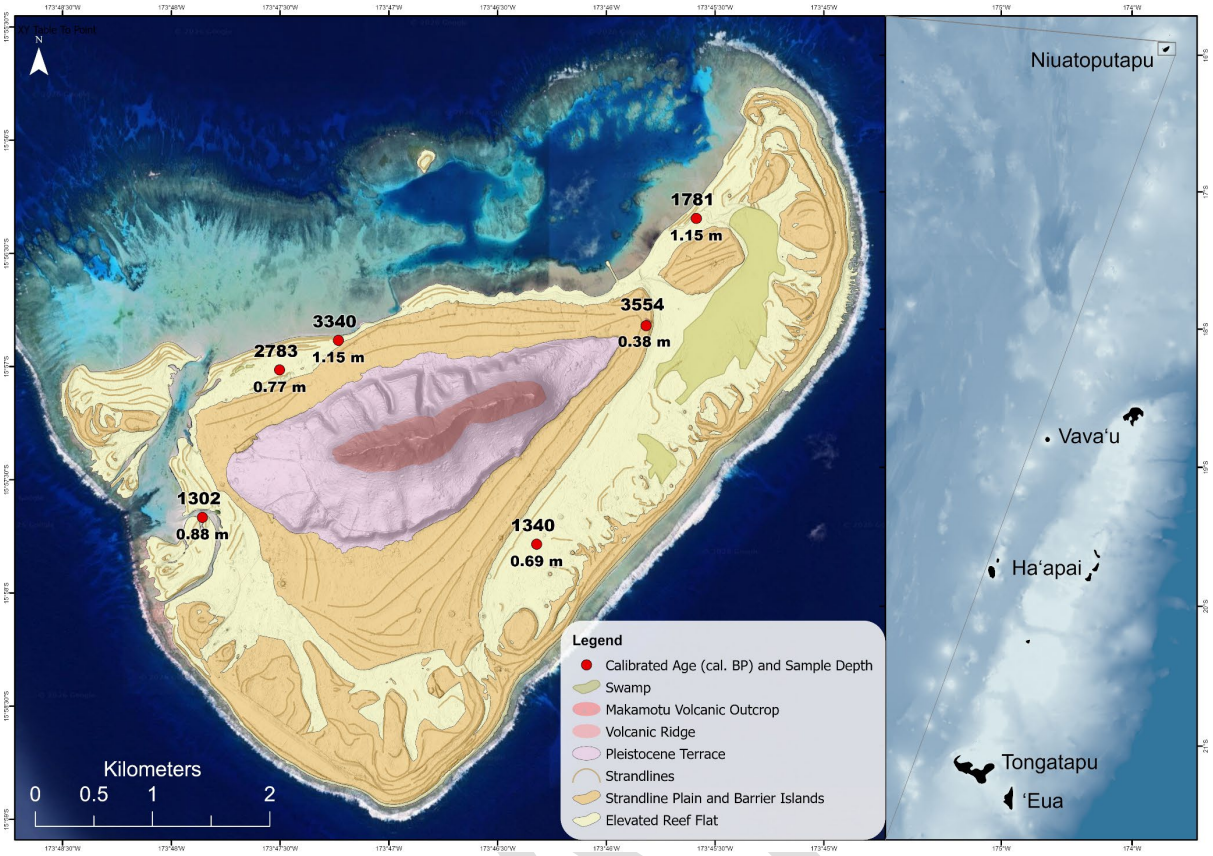

Figure 1: New geomorphology map of Niuatoputapu displaying geomorphic units and initial radiocarbon dating results.

Innovations in Micropaleontology for Quaternary Science.

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Micropaleontology has declined in prominence in recent years, with attention shifting toward emerging analytical and modelling techniques and with the retirement of many leading micropaleontologists. Yet during this period, the field has undergone substantial, often under-recognised innovation. These advances provide powerful new tools for addressing key questions in Quaternary physical oceanography, biodiversity, and global climate dynamics.

Recent methodological developments span both data acquisition and data interpretation. Automated microfossil identification technologies are accelerating sample processing and improving taxonomic consistency. Novel statistical frameworks are enabling more robust reconstructions of past environmental conditions, while progress in isotopic analysis and elemental mapping is expanding the suite of proxies available for reconstructing oceanographic change. Together, these innovations position micropaleontology to make renewed and significant contributions to understanding Earth's Quaternary history.

This poster highlights the breadth of recent methodological advances and argues for a re-evaluation of micropaleontology as an essential, future-focused component of Quaternary science. By showcasing the capabilities of modern micropaleontological tools, we aim to "bring back the love of micropal" and re-engage the community with the unique insights this field continues to offer.

Wetting and drying processes alter stone artefact distribution in clay-rich soils.

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POSTER

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Soils that contain swelling clay minerals (e.g., montmorillonite) expand and contract during wetting and drying, causing movement within the soil profile. This process, known as argilliturbation, can alter artefact distributions, destroy stratigraphy, and complicate the interpretation of archaeological deposits. Our study investigates the influence of argilliturbation on stone artefact distribution in a clay-rich sediment basin on Middle Gidley Island in the Murujuga rock art province, northwest Australia. We report on an experiment that quantified the movement of artefacts following wetting and drying treatments using the local soil and other contrasting soil textures. Six weekly wetting and drying cycles were conducted on 27 soil experiment containers, which contained one of three soil types and embedded (non-cultural) stone artefacts. The soils used were the Middle Gidley clay-rich soil (MG-Soil), a pure quartz sand (S-Soil), and a mixed soil (X-Soil; 25wt% MG-Soil and 75wt% S-Soil). The containers were imaged using CT-scanning before and after the experiment, and the movement of artefacts was calculated using 3D image correlation (Figure 1).

The results demonstrated that wetting and drying processes can cause movement of artefacts and disrupt stratigraphy in a variety of soils, most notably in the vertical direction. Argilliturbation caused upward movement of all artefacts within the MG-Soil (average = 4.3 mm). Artefacts also moved upwards in the X-Soil (average = 1.2 mm) but was less pronounced. In contrast, all but one artefact within the S-Soil moved downwards (average = 2.0 mm), indicating sinking within the sand matrix. The archaeological assemblage at Middle Gidley Island was interpreted considering the experimental results, which indicated that artefacts found on the surface of the sediment basin likely reflect artefacts deposited at different times – that have been pushed upwards and concentrated at the surface by argilliturbation. We discuss the wider implications of these post-depositional processes for archaeological sites.

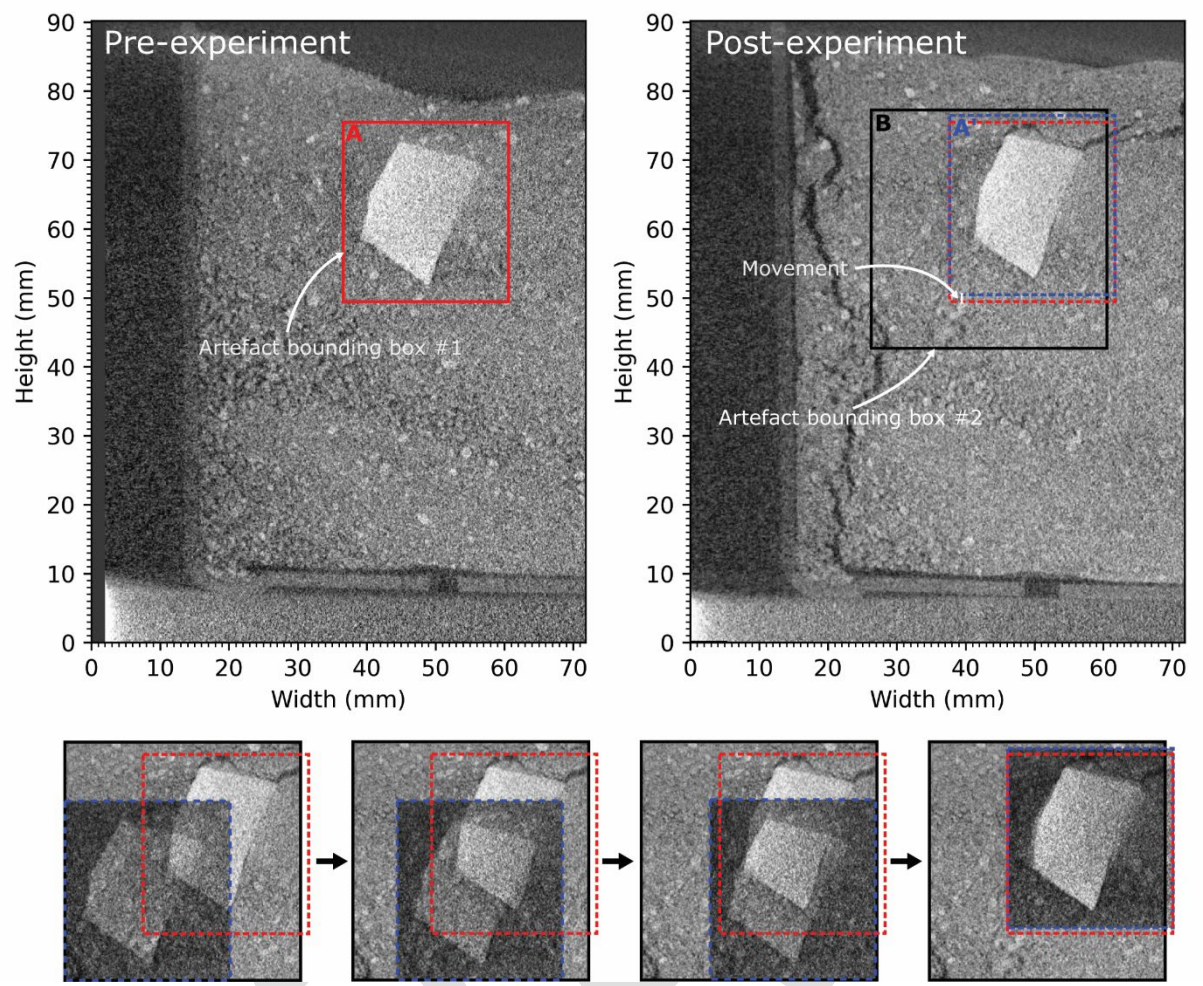

Figure 1: CT-scan imagery showing: Top) a slice through the experiment container pre- and post- wetting and drying experiment and, Bottom) illustration of the computational method to measure artefact movement.

Late Holocene hydroclimate on Kangaroo Island, South Australia: assessing the potential of speleothems from Kelly Hill Caves.

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POSTER

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Across southern Australia, prolonged periods of water scarcity pose a serious threat to human infrastructure and ecosystem stability, affecting bushfire occurrence and severity. The magnitude of recent drought and bushfire events underscores the importance of developing a deeper understanding of regional hydrological and environmental responses to climatic variability. Paleoclimatic data is essential to assess hydrological spatio-temporal variability; however, the intermittent aridity of southern Australia undermines the development of continuous paleoclimate archives. In South Australia, Kangaroo Island exemplifies this principle due to its endemic ecology and susceptibility to wildfires and droughts. Kelly Hill Caves (KHC), part of Kangaroo Island's southwestern coast, offers a site for paleoarchive retrieval. Previous investigations and hydrological monitoring indicate that KHC's karst system conditions are capable of recording recent and multi-scale variations in the oxygen isotope composition of precipitation. Here, we present progress on planning the development of a late Holocene speleothem-based KHC paleoclimatic record. Preliminary investigations into the environmental and geomorphological site details are reported to substantiate initial climate and precipitation interpretations. These results provide context for developing a Kangaroo Island climate record that can be applied to a broader climatic framework. Prospectively, our record will address a major geographical and temporal gap in past southern Australian hydrological, climatic, and environmental records.

Holocene hydroclimate variability in the south pacific: new insights from high-resolution stalagmite proxy records from Tonga.

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The scarcity of high-resolution palaeoclimate records from the Southern Hemisphere limits our understanding of Holocene hydroclimate variability and its drivers. To address this, we present new results from five U-series dated stalagmites collected from two different cave environments in the Kingdom of Tonga: Ana Hulu (a warm, shallow coastal cave) and Ana Maui (a cooler, elevated forest cave). Together, these samples provide an almost continuous, high-resolution hydroclimate archive spanning the last ~12,500 years.

The stalagmites exhibit diverse growth rates (50–300 μm/year) and lamination styles, allowing for the potential development of annually resolved records. Age modelling is being refined using automatic lamina counting techniques in combination with Dynamic Time Warping (DTW), enhancing chronological precision.

A multi-proxy approach, including $\delta^{13}C$ and $\delta^{18}O$ stable isotopes, LA-ICP-MS trace elements, synchrotron XRF data, and petrographic analyses, is applied to assess infiltration regimes and hydroclimate dynamics. This integrated framework allows for a robust reconstruction of the behaviour of the South Pacific Convergence Zone (SPCZ), offering new insight into tropical climate variability across the Holocene in the South Pacific region.

Late Quaternary Palaeo-environments of Jumping Grass Marsh, North Stradbroke Island (Minjerribah), South-east Queensland.

Ngata, Bonnie[1]

POSTER

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North Stradbroke Island (Minjerribah) in the Moreton Bay region of Australia forms part of a globally unique and complex system of the coastal sand masses along the South-east Queensland coast. The island's climatological setting, as well as highly varied elevation, diverse vegetation communities and hydrological factors, have shaped a diverse range of wetland types on the island. Core sampling at some of these wetlands has yielded well preserved and informative palaeorecords of late Quaternary landscape evolution, and climate, ecosystem and land-use change. Nonetheless, many of Minjerribah's wetlands lack thorough palaeoenvironmental records, resulting in incomplete knowledge of past environmental change, as well as cultural heritage and human impacts. The Quandamooka-Yoolooburrabee Aboriginal Corporation (QYAC) have highlighted concerns about possible threats to Jumping Grass Marsh, and a need to expand knowledge of its environmental and cultural history to inform future management decisions. Jumping Grass Marsh is located in the northern edge of the township of Dunwich, and is surrounded closely by urban settlement, including roads, residential buildings and QYAC offices. Jumping Grass Marsh is primarily a wire rush dominated system, with the characteristic vegetation located centrally bounded along its edges by recent encroaching paperbark swamp, with a significant portion of paperbark swamp directly adjacent to the East Coast Road. While previous sampling efforts have concentrated on the wire rush dominated wetland area, this presentation provides insight into palaeoenvironmental records obtained from the paperbark dominated section of Jumping Grass Marsh, where geochemical and palynological evidence enhance a growing understanding of significant events, drivers and impacts of past climate, ecosystem and land-use change in this wetland site.

Last Interglacial climate variability and polar ice-sheet meltwater events recorded in New Zealand speleothems

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The Last Interglacial (129–116 ka) was characterised by temperatures 1-2 degrees warmer than pre-industrial values, leading to smaller ice sheets than today and consequently higher sea levels. This makes it an ideal period for studying ice-sheet and climate responses under conditions similar to the present day. Here, we present new speleothem palaeoclimate records from South Island, New Zealand. Located under the path of the Southern Westerlies, New Zealand's climate is potentially sensitive to shifts in atmospheric cells triggered by polar ice-sheet meltwater pulses. Atmospheric responses to these pulses are identified through high-resolution multiproxy analyses (stable isotopes, trace elements, TEX_{86}), with timing constrained using high-density uranium-thorium dating. These well-constrained speleothem chronologies allow precise determination of the timing of prominent climate perturbations during the Last Interglacial and exploration of their potential connections with polar ice-sheet meltwater events from both hemispheres recorded in ocean sediments. This research is aimed at improving our understanding of hemispheric teleconnections and ice-sheet meltwater-event phasing, which is crucial for testing ice-sheet model simulations and evaluating future responses to global warming.

Using Python and Qt to improve stable and radiogenic isotope data processing workflows.

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POSTER

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As data processing workflows in analytical geochemistry become increasingly sophisticated, there is a growing need for software solutions that enable analysts to implement complex procedures in an accurate, efficient and reproducible manner. Python is a general-purpose programming language that has much to offer in this respect: it is relatively easy to learn, facilitates rapid code development, encompasses well-developed libraries for scientific computing, and often can be dovetailed into workflows with existing commercial software packages. Complementing this, Qt is a well-established and robust cross-platform development framework for creating graphical user interface applications. It is widely used in both commercial and open-source software, including VirtualBox, Mathematica and TeamViewer. Although written in C++, the Qt framework can be accessed from Python via bindings such as PySide and PyQt, enabling the rapid development of feature-rich, stable and extensible desktop applications for data processing.

In this contribution, we demonstrate how Python–Qt applications have been implemented within the Stable Isotope Facility and U–Th–Pb dating laboratories at the University of Melbourne. We present examples including: (i) processing carbonate stable isotope data acquired by continuous-flow and dual-inlet IRMS, (ii) processing stable water isotope data collected by CRDS, and (iii) performing U–Pb age calculations for geologically young samples, where initial radioactive disequilibrium must be accurately corrected for by solving complicated equations. These case studies illustrate how this approach can streamline routine workflows and improve the accuracy and reproducibility of results.

Biomarker δD analyses reveal the impact of the southern Westerlies on Western Tasmania's hydrology.

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POSTER

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During the Late Pleistocene the spatial extent and variability of the southern Westerlies varied in response to southern hemisphere temperature fluctuations. One example is the Antarctic Cold Reversal (ACR) which coincides with the warm Bølling-Allerød interstadial in the northern hemisphere. Tasmania is directly influenced by the southern Westerlies, however the impact of shifting Westerlies and temperature on the hydrology of terrestrial ecosystems in Tasmania during such periods are not well understood. This is in part due to the scarcity of direct hydrological reconstructions of the precipitation-evaporation balance.

Here we present a first attempt to reconstruct past evaporation during the Late-Pleistocene-Holocene transition (ca. 19,000 until 8,000 years before present) using compound-specific δD on n-alkanes from three lakes in Western Tasmania (Lake Selina, Blythe and Basin). These selected closed basin lakes are relatively small and are within a region characterised by a positive relationship between rainfall and windspeed. As such, these lakes are sensitive to changes in the regional precipitation-evaporation balance and are thus suitable for hydrological reconstructions using stable isotopes.

Within all three lakes, the δD-signals of aquatic short chain (n-C_{23} and n-C_{25}) and terrestrial long-chain (n-C_{31}) n-alkanes reveal a consistent pattern. Our results show that short-chain n-alkanes are isotopically enriched compared to long-chain n-alkanes, which is likely due to their sensitivity to changes in the evaporative enrichment of lake water, which in turn is linked to the past precipitation-evaporation balance. While a local calibration of leaf wax pattern is currently underway, to refine our hydrological interpretation for future studies applying this method, we conclude that changes in the aquatic δD signal in all three lakes during the Late Pleistocene-Holocene transition suggest a clear relationship between the southern Westerlies and the regional hydrology (wetter versus drier) in Western Tasmania.

Tracking Quaternary flooding and aridification in Australia's deserts as inferred from the sediments of Lake Yamma Yamma (QLD).

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POSTER

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[4]School of Science, University of Wollongong

Major flood events in central, arid Australia are controlled by the Indo-Australian Summer Monsoon (IASM) runoff from tropical Australia. However, underlying climate mechanisms remain unresolved. The ephemeral Lake Yamma Yamma (LYY) in south-western Queensland is an excellent archive for IASM runoff via the Cooper Creek. This project plans to extract a 30-meter sediment core from LYY (estimated age: 600 ka). Until a 30-meter core becomes available, current work centres around two other cores from LYY: cuttings from a 100-meter core 'BARROLKA-1' (recovered early 1960s, estimated age: 2 Ma), and a 5-meter pilot core (retrieved 2024, age at least 70 ka). Age estimates for the 100-meter and 30-meter cores are based on published sedimentation rates from nearby Wilson Depression. The 5-meter core was dated with Optically Stimulated Luminescence (OSL).

Both the 100-meter and 5-meter cores are currently subject to geochemical and sedimentological analyses (major, minor, trace elements, εNd, $^{87}Sr/^{86}Sr$, grain size) to deduce sediment sources and sediment deposition processes, and thus, runoff patterns, climate shifts, and environmental changes. Dating by means of meteoric ^{10}Be is currently undertaken for BARROLKA-1.

Preliminary Nd/Sr isotope ratios for the 5-meter core indicate that the sediment input to LYY is dominantly transported via Cooper Creek (and not from local catchment sources). If this is true, runoff from tropical Australia was the main sediment input for LYY for the last ca. 70 ka. Distinct cyclicity in Nd/Sr might represent an additional and varying sediment input next to Cooper Creek, most likely from an aeolian and/or local fluvial sources. For core BARROLKA-1, prominent changes in depositional environment are inferred from grain size data. Fine-grained sediments (<95 µm) dominate below 60 meters, overlain by sandy deposits until ca. 42 meters. The 'sandy' fraction gradually decreases towards the top, returning to mostly fine-grained, almost sand-free sediments above 18 meter. This pattern is not mirrored in preliminary elemental data, potentially indicating changes in depositional characteristics instead of sediment sources.

Ancient DNA from Lake Sediments: Reconstructing Pre-European Biodiversity Baselines in South-Eastern Australia.

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POSTER

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Accurate reconstruction of pre-European biodiversity is critical for appropriate conservation and restoration, yet traditional palaeoecological methods face significant taxonomic limitations in Australian environments. Pollen analysis cannot distinguish species within diverse families, whilst microfossil records exclude taxa that produce no identifiable remains. Genomic techniques overcome visual identification constraints inherent in traditional methods, enabling detection of cryptic, transient, or microfossil-absent taxa previously undetectable in sediment records. Here, we present a comprehensive application of ancient sediment DNA (sedaDNA) techniques to a terrestrial southeast Australian billabong record, addressing critical knowledge gaps in baseline biodiversity reconstruction.

We analysed an existing billabong sediment core from along Naarm/Melbourne's Birrarung (Yarra River); previously characterised using traditional proxies (pollen, charcoal, grainsize, geochemistry). Here, our aim is to reconstruct pre-European species compositions with species-level resolution and evaluate sedaDNA feasibility for Australian terrestrial environments. Lake sediments provide integrated records of both aquatic and catchment terrestrial communities through wind and water transport of genetic material across landscapes.

Our approach builds upon successful global sedaDNA applications whilst pioneering terrestrial methodologies for the Australian context. Results demonstrate that sedaDNA successfully reconstructs detailed pre-European community assemblages, providing unprecedented taxonomic resolution compared to conventional approaches. These findings challenge wilderness-based conservation paradigms by revealing landscapes actively managed by Wurundjeri Woi Wurrung. This study establishes sedaDNA as a transformative tool for Australian biodiversity research, generating accurate species-level baselines essential for evidence-based ecosystem restoration. The methodology addresses

fundamental limitations in palaeoecological reconstruction whilst integrating genomic innovation with Aboriginal knowledge systems. Our findings provide government bodies and Aboriginal communities with precise benchmarks for restoration projects and cultural landscape management, demonstrating the broader conservation applications of sedaDNA across Australia's diverse terrestrial ecosystems.

Quaternary environments of the Mt Gambier region, Limestone Coast, South Australia

Rowlands, Lucy

POSTER

Affiliation/s

The Mt Gambier region of South Australia represents a mature karst landscape featuring extensive cave systems, punctuated by areas of Pleistocene-Holocene hotspot volcanism. The areas deep, phreatic cave systems and cenotes function as critical taphonomic traps, preserving assemblages of Pleistocene vertebrate fossil and megafaunal remains. Integrated with data from the associated Australian Research Council (ARC) Linkage Project "Deep time extinctions and environments in Australian underwater caves," this presentation aims to provide terrestrial environmental context to regional megafaunal extinction through a multi-proxy, palynology focused, palaeoenvironmental reconstruction of the Marshes Wetland Complex. This presentation will provide an overview of regional vegetation dynamics, fire regime variation, hydrodynamics, and long-term climactic shifts throughout the Holocene, using modern analytical techniques to expand upon previous palaeoenvironmental research, undertaken by J.R. Dodson and I.B. Wilson in the Mt Gambier region during the early 1970s. This detailed reconstruction will establish a pre-colonial baseline for the continued restoration of key ecological sites, after significant regional anthropogenic transformation, following colonisation.

Strontium isotopes unravel late Quaternary groundwater, surface runoff and rainfall recharge at Lake Ohrid (Balkan Peninsula).

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*Equal contribution

POSTER

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Understanding hydrologic variability is essential to better understand implications of future climate change, specifically in the dry climates such as the Mediterranean, where climate forecast models suggest significant drying. Palaeoclimate studies aiming at a better understanding of hydrologic dynamics usually focus on qualitative to quantitative reconstructions of the amount of rainfall (e.g. via pollen-based), or the precipitation to evaporation ratio (e.g. via stable isotopes of lake carbonates). However, most studies on past hydrologic change neglect groundwater recharge, which can affect the lake's water balance and geochemistry, and even vegetation structures via soil moisture. This is largely due to the lack of appropriate analytical tools to study past hydrologic change simultaneously accounting for past rainfall, evaporation, and groundwater cycling.

Radiogenic strontium isotope ratios ($^{87}Sr/^{86}Sr$) are a powerful and well established tool for water source mixing, since it is easily soluble from rocks; the isotopic value thereby depends on the age of the source rock. Strontium can readily be incorporated into calcite minerals, where it then carries the radiogenic signature of the source water without significant isotopic fractionation. Importantly, strontium isotopes are not affected by evaporation such as oxygen and carbon isotopes, indicating that it can become a powerful, yet widely underused tool to estimate groundwater recharge versus direct precipitation and river runoff in palaeoclimate studies.

The influence of groundwater recharge on Lake Ohrid's (North Macedonia, Albania) proxy data interpretations has been neglected until today, even though surface and sub-lacustrine karst springs contribute 55% to the overall water input today; with the remaining 45% being attributed to direct precipitation and river runoff. In comparison to published geochemical and stable isotope data, initial results from the Last Interglacial cycle provide evidence that groundwater recharge becomes more prominent during relatively drier episodes, whereas surface runoff and direct precipitation dominate during over wetter periods.

Reconstructing Environmental Histories of Western Moreton Bay.

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POSTER

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Mangroves and saltmarshes provide myriad ecological functions including carbon sequestration and coastal protection. Within Moreton Bay these habitats are internationally recognised Ramsar wetlands for their key role in supporting ecological diversity. The extent and health of these ecosystems have changed significantly, and they appear to be under threat from anthropogenic drivers including sea level (SL) rise and rainfall input. However, only short records of baseline change are available since the mid-20th century and relatively little is known about the evolution of these environments prior to colonisation. Palaeoecological reconstructions can aid our understanding of long-term environmental drivers of change in these systems which is important in enhancing management outcomes. Sediment cores were collected from a saltmarsh in Empire Point and analysed to establish a palaeoenvironmental history of the coastal landscape and examine potential drivers of change. This study used a multiproxy approach including sedimentological, X-Ray Fluorescence, Palynological and Loss on Ignition analyses supported by a limited ^{14}C chronology. The results show the evolution of the Empire Point coastline from a possible Pleistocene land surface, recording the mid-Holocene SL highstand as seen in previous studies, as well as European colonisation signals. This pilot study provides the first date for the initiation of mangroves within Moreton Bay at ~1450cal. yrs BP, although it is spatially limited. The evolution of the saltmarsh at this site appears to occur recently, apparently concurrent with European colonisation or the end of the Little Ice Age. Evidence is presented for anthropogenic alteration of the saltmarsh by local hydrological changes and coral dredging operations which occurred during the 20th century. These findings of an increasingly dynamic coastline warrant further research to determine the timing and drivers of recent ecological changes. An increase in study resolution and chronological control supported by ANSTO is now being conducted to disentangle these signals.

Ancient rainwater preserved in speleothems reveals past precipitation source variability in semi-arid southeast Australia.

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Moisture-limited drylands are projected to expand in southeast Australia as the Southern Hemisphere westerlies shift poleward under Hadley Cell expansion. Improving adaptation strategies to encroaching dryland conditions depends on understanding how regional moisture sources have varied in the past. Recent research suggests southeast Australian speleothems show increased growth during glacial periods, indicating enhanced effective precipitation (precipitation minus evaporation). However, it remains uncertain whether this reflects migration of the Southern Hemisphere westerlies, changes in evaporative demand due to cooler temperatures, or both. Speleothem growth alone cannot resolve the drivers of moisture availability, suggesting a need to develop records of precipitation source changes.

Past precipitation source pathways can be reconstructed using speleothem fluid inclusions, which preserve fossil drip water within calcite formed during speleothem growth. The $\delta^{2}H$ and $\delta^{18}O$ composition of this water reflects the isotopic composition of ancient rainwater, constraining its transport. Here we present fluid inclusion results from a suite of speleothems from Cliefden Caves (NSW), a semi-arid site sensitive to the shifting influences of mid-latitude and tropical storm tracks. By comparing the isotopic composition of fossil drip water and modern precipitation, we reconstruct changes in precipitation source pathways, revealing new insights into how precipitation variability influenced past moisture availability in semi-arid southeast Australia.

Deepening our understanding of changes in plant communities in response to fire on Kangaroo Island using sedimentary ancient DNA.

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With the increasing frequency and intensity of bushfires, it is necessary to characterise past ecosystems to better predict future changes. Kangaroo Island (KI) represents an important location to study past environmental change due to its high level of endemism and complex fire history. Our knowledge of KI's history has been improved by recent work on sediment cores from Lashmars Lagoon. These studies used geochemistry, charcoal, and pollen to document and quantify the connections between increasing aridity and fire frequency since the mid-Holocene. However, with these methods our understanding of the plant communities and how they changed is confined to the family level for many taxa. To generate more detailed taxonomic records, we plan to examine sedimentary ancient DNA (sedaDNA) recovered from the same and new KI sediment cores. SedaDNA has become an increasingly powerful tool to examine diverse historic and contemporary plant communities. However, sedaDNA analysis is reliant on good-quality taxonomic resolution in genetic reference libraries. To gain a more detailed picture of the changes in the plant community on KI, we aim to increase the taxonomic resolution that can be achieved for plant community sedaDNA data from Lashmars Lagoon. We will expand taxonomic assignment approaches from using single-gene databases to NCBI RefSeq genomic databases, which contain nuclear, mitochondrial and chloroplast genes of plant communities. Second, we will build a custom genetic reference library from herbarium specimens including multiple chloroplast and nuclear genes from key plant species on KI – aiming to achieve species level resolution. Our overall goal is to generate a detailed map of KI vegetation change through the Holocene to present and build a framework for other paleoecology studies wanting to complement paleo-records with sedaDNA data in Australia.

Foragers or miner-harvester- fishers?
The archaeology of Mithaka country.

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1Mithaka Country in the desert channels of southwestern Queensland covers an area slightly larger than Belgium. Archaeological and palaeoenvironmental research conducted over the past nine years has revealed an extensive archaeological and ethnohistoric record. This record includes large quarry "megasites," bioarchaeological evidence for sedentism, plant harvesting practices, extensive stone arrangements, village locations, and infrastructure associated with water storage and aquatic resource extraction.

These findings challenge prevailing models of Aboriginal land use and subsistence. They demonstrate substantial landscape modification and management, highlighting the limitations of terms such as "foragers" for characterising certain Aboriginal social and economic systems.