
# Tuesday 25th June

# Abstracts for oral presentations

# Recognizing the fundamental roles of natural forces in cultural landscapes for informed management: a case study from lutruwita/Tasmania

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Aboriginal people have occupied Australia for at least 65,000 years and more than 40,000 years in the continental island of Tasmania, and their cultural practices, especially burning, are thought to have largely created the landscape that persisted in Australia until colonial settlement around 230 years ago. This pre-colonial landscape is often described as generally open/grassy, and less woody, maintained by frequent low-intensity fires. The legacy of this cultural burning is thought to be responsible for many treeless vegetation communities in Australia today, including in rainforest biomes. Here we ask: Is the long-term persistence of treeless vegetation (moorland) in a Tasmanian area climatically suited for forests due to recurrent burning, climate, or other factors? As opposed to previous hypothesis and proposals of a fire-shaped cultural landscape, we found that moorland and forest in southern Tasmania have occupied the same habitat for over two millennia, and neither past climate change nor frequent burning affected the stability of the vegetation mosaic. Observed localized environmental factors, such as topography and edaphic conditions, are the plausible primary stabilizing factors of the forest-moorland mosaics in the Tasmanian Wilderness World Heritage Area (TWWHA). This finding contrasts with the dominant ecological paradigm of fire-driven landscape dynamics currently used to manage the TWWHA, and the ecological basis of fire management in the area needs to be refined.

# Palaeoeoclogical insights into last glacial to Holocene vegetation and fire dynamics from a monomictic lake within lowland Huon Pine (*Lagarostrobos franklinii*) rainforest adjacent to the Gordon River, Lutruwita/SW Tasmania.

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Perched Lake is a monomictic lake nestled 20m above the Gordon River and is surrounded by the ever increasingly vulnerable Huon Pine (*Lagarostrobos franklinii*) rainforest environment within the Tasmanian Wilderness World Heritage Area, Lutruwita/SW Tasmania. The lake is also in close proximity to Kuta Kina Cave (Fraser Cave), a cave site of high cultural significance that show a deep and intimate connection between the southern latitudinal extremes of our region and palawa/pakana communites over many millennia. Over the last two centuries increased fire occurrence, changing climate and a legacy of extensive harvesting of Huon Pine timber in the 19th and 20th centuries has reduced the stand cover by more than 90% and has elevated the need for greater understanding of the long-term ecological dynamics of this significant cultural landscape and threatened long-lived conifer. Cores collected in November of 2023 have been analysed for pollen, charcoal and other proxy data to reconstruct the palaeoenvironmental conditions surrounding Perched Lake spanning the last ~40,000 years. Our findings indicate that Perched Lake ecosystems exhibited remarkable resilience to climatic fluctuations, with shifts in vegetation composition and lake dynamics reflecting past climatic oscillations. Furthermore, the multi-millennial fire history shows that climate, fire regimes, and human activities have all played a role in shaping Huon Pine rainforest of today.

# Response, resilience and recovery of Tasmania's endangered Pencil Pine using a multi-archive palaeoenvironmental record

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Climate change and extreme events are having severe impacts on terrestrial ecosystems. These include: the deterioration of ecosystem structure and function, a reduction in the resilience and adaptive capacity ecosystems and an increase in tree mortality resulting from intensifying droughts and fires. Such impacts are particularly observable in long-lived fire-sensitive tree species, in which phenological response and adaptive capacity are limited by demographic constraints. Climate change is shifting the core climatic range both latitudinally and altitudinally at a rate exceeding their migratory capacity, resulting in the stranding of extant populations in disequilibrium with climate. Moreover, in areas where disturbance from fire is also increasing (such as Australia), these populations experience sub-optimal conditions for reproduction and post-fire recovery that can lead to fire-driven collapse.

The Tasmanian Wilderness World Heritage Area (TWWHA) is home to globally significant and highly valued flora with ancestries in the supercontinent of Gondwana. During the 2016 austral summer wildfires ravaged the Central Plateau decimating and severely threatening stands of core refugia of extremely fire-sensitive palaeoendemic conifer *Athrotaxis cupressoides* (Pencil Pine). Despite significant funding to manage these threatened ecosystems, the long-term impact of climate change on the resilience of these systems remains uncertain, alongside a dearth in knowledge of how to apply the most efficient and cost-effective management strategy. Here, there is a need to develop a deep, long-term understanding of these long-lived ecosystems to execute well-informed land-management strategies for their future preservation.

To do so, this research applies palaeoecology (fossil pollen, charcoal), palaeoclimatology (isotope, trace element analysis) and geochemistry, to investigate the long-term evolution of fire-sensitive Pencil Pine ecosystems across the Central Plateau throughout the Holocene (ca. 11,700 years. Species distribution modelling is explored to understand the relationship between ecosystem evolution and Pencil Pine distribution in the contemporary landscape.

Figure 1: Photograph of Pencil Pine (*Athrotaxis cupressoides)* surrounding one sediment coring site within this study (Graceful Plunge Lagoon - TAS2202) on the Central Plateau in Tasmania.

# Holocene Environments of the Southwest Corner of Tasmania

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The Holocene landforms of Port Davey, Bathurst Harbour and Melaleuca Inlet in the southwest corner of Tasmania are key elements of a globally unique estuarine system, which contributes to the Outstanding Universal Value of the Tasmanian Wilderness World Heritage Area (TWWHA). Palynological, charcoal and X-ray fluorescence data will be presented for three locations from these coastal environments. This research provides information on when these systems formed and how they have responded to climate, sea level and anthropogenic factors for around the last 7,500 years. The first site, 'North River', a scrubby sedgeland, is situated near the mouth of the North River and a 275 cm core was collected, which covers the last 7,540 cal. years BP; the second site 'Puffin Creek' is a sedgeland located near Melaleuca Inlet and a 207 cm sediment core, with a basal age of 3,625 cal. years BP was collected; and the final site 'Old River' is a freshwater marsh system directly adjacent to the mouth of Old River and from which a 89 cm core was collected and covers the last 740 cal. years BP. Sediment cores collected from the coastal mires in the region allow examination of their formation process, depositional rates and responses to Holocene environmental change. This information, together with data that characterises the present wetland dynamics, provides important findings for the management of these systems, particularly in terms of fire regimes, potential response to sea level rise and anthropogenic influences including visitor impacts.

Figure 1. Sediment core collected in April 2023 from Swan Cove, near Old River

# Reclaiming the importance of the grasslands of Long Island, Furneaux Group (Bass Strait), Lutruwita/Tasmania

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Grasslands are often assumed to be the result of relatively recent land management practices, expanded for pastoralism following European colonisation. This presentation draws on recent palaeoecological evidence from one remote island in the Bass Strait to show that the grasslands have existed for at least 1,000 years. This indicates that these grasslands need to be considered central to conservation and land management strategies.

We present the results of the first palaeoecological study of Long Island. Core samples were collected as part of a wider study on the vegetation and fire history of the Furneaux Group, located in the eastern Bass Strait in collaboration with the Truwana Rangers, the Tasmanian Aboriginal Centre and local land managers.

Today, forest covers the eastern corner of Long Island, and the western side is dominated by herbs and sedges. While little is known about the long-term ecological history of this remote island, an historical source from 1828 indicated that the island was heavily forested. This has led to the assumption that the grasslands that characterise the island today are the result of a dramatically altered vegetation regime, imposed by fire, clearance and grazing animals introduced by whaling and pastoralist colonisers in the early 19$^{th}$ Century.

We compare palaeoecological evidence, historical vegetation changes inferred from aerial photo analysis, and the island's fire regime to develop a comprehensive record of the island's long-term ecology. The results show that, despite recent forest expansion on the eastern side of the island, grasslands have been a dominant feature of Long Island's vegetation for at least 1000 years, predating European colonisation. This is significant as it suggests that the current grasslands are an enduring and significant vegetation community on the island, and as such, the conservation and management of these grasslands needs to be prioritised alongside the conservation of other ecological communities.

# Constraining and comparing vegetation recovery and landscape responses between the Waikato lowlands and Hawke's Bay region after the 1.8 ka Taupō eruption, New Zealand

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Lake sediment cores are valuable archives for assessing periods of past environmental change, landscape development, and climatic shifts through time. Using historical cores from Lake Tūtira (Hawke's Bay) and Lake Rotokauri (Waikato), novel insights into the ecological impacts of the 1.8 ka Taupō eruption (New Zealand) on starkly contrasting ecosystems were provided through targeted, fine resolution sampling at millimetre-scales around primary tephra deposits. Lake Tūtira is situated within a highly active and complex catchment that is sensitive to climatic, tectonic, and volcanic drivers, which have episodically disturbed the catchment and generated large volumes of sediments. Through a combined litho- and palyno-facies approach, immediate volcanic impacts of the Taupō eruption on the catchment landscape and vegetation from successive episodes of ashfall were able to be distinguished from the devastating and prolonged effects of nearby ignimbrite emplacement. In contrast, coarse ash was deposited irregularly across the Waikato lowlands during the final and most explosive phase of the Taupō eruption. Immediately above the tephra is evidence of ashfall- and fire-induced forest disturbance, reflecting an opening-up of the podocarp-hardwood and kauri forest surrounding Lake Rotokauri from a combination of tephra deposition, lightning strikes, and burning both during and after the eruption. On a regional scale, forest recovery across the Waikato lowlands was likely prolonged by the sporadic occurrence of fires under inferred arid, El Niño-like conditions, with compositional adjustments (i.e., increased kauri) likely reflecting an adjustment to drier climates accelerated by volcanic disturbance. These contrasting insights into vegetation responses and timescales of landscape recovery were only possible due to targeted, fine resolution sampling, thereby demonstrating the value of millimetre-scale palaeoecological analysis for assessing past eruptive impacts.

# Unravelling taphonomic bias and varied sediment transport dynamics in marine pollen records from offshore Aotearoa

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In Aotearoa-New Zealand, where continuous records of vegetation and climate change beyond the recent glacial-interglacial cycle are scarce, marine sedimentary records offer unique opportunities to explore climate dynamics over longer timescales. However, when utilizing pollen in these records for vegetation reconstruction, we need to consider the impact that differing pollen transport mechanisms could have in biasing a pollen record. One of Aotearoa's few long records is from marine core Ocean Drilling Program (ODP) 1123, which has yielded a pollen-based record of vegetation change covering the entire Pleistocene (Mildenhall et al., 2004) at a resolution of 10-50ka. With the core site located ~500km east of the North Island, long-distance pollen transport via wind and ocean currents resulted in a strong taphonomic bias in the record. Mildenhall (2003) noted that spectra were dominated by conifer pollen and fern spores, due to their long transport abilities and robust structures, respectively, while angiosperm pollen was markedly under-represented. In this study, we compare the pollen record from ODP-1123 with a pollen record recovered from the more proximal sediment core International Ocean Discovery Program (IODP) U1520D, situated at the base of the Māhia Canyon (100km offshore). Unlike at ODP-1123, pollen at IODP-U1520D is emplaced by turbidity currents derived directly from the continental shelf. Through tephrochronology, foraminiferal analysis, stable isotopes, CT scanning, XRF data, and grain-size analysis, we examine the relationship between turbidite sediment facies and pollen assemblages in IODP-U1520D. The resulting new, high-resolution (~3ka) record of pollen and vegetation change in the Early Pleistocene is compared with ODP-1123 to assess the influence of different sediment transport processes on vegetation and climate records from marine sediment cores. Our study sheds light on the complexities of reconstructing past climate and vegetation from offshore sediment cores, highlighting the importance of considering sediment transport mechanisms when interpreting marine sedimentary records.

**References:**

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# Quantifying late Quaternary rainfall seasonality for the Southern Hemisphere

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Rainfall seasonality depends on large-scale climate systems, as well as local effects such as continentality and topography. Monsoonal regions receive most of their rainfall in the summer, whereas mid to high latitude regions may receive most of their rainfall from the westerly winds during the winter. Being able to reconstruct these patterns for the whole of the Southern Hemisphere would provide important insight into the movements of these vital climate systems through time. We use the Asteraceae: Poaceae pollen ratio on fossil pollen records from across the Southern Hemisphere to determine rainfall seasonality dynamics going back 36 ka. Despite the apparent failure of the ratio in mountainous regions, possibly due to rain shadow effects, some interesting patterns emerge when comparing the continents. The two southern last glacial maxima (33-32 ka and 23 ka BP), start of the Holocene (11 ka BP) and mid-Holocene (6.5-5.5 ka BP) were periods of change, with opposite patterns occurring on the three continents. On the other hand, the global Last Glacial Maximum (22-17 ka BP) was a period of simultaneous change across the Southern Hemisphere. This may be due to a strong coupling with prevailing climate forces, possibly linked with the waning of global ice masses. When the ice masses were in a stable maxima or minima, local or regional forces dominated, leading to the lack of synchronicity between the continents at these times. This has strong implications for the interpretation of other records from across the Southern Hemisphere.

# Coring in a hard land: recovery of palaeo-environmental records from Channel Country

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The Channel Country, in southwestern Queensland is a land defined by a pronounced boom and bust cycle linked to the highly variable precipitation produced by the El Niño Southern Oscillation (ENSO) phenomenon. In the dry periods, the flat clay-dominated floodplains bake and crack under the hot sun and surface waters become restricted to only the widest and deepest parts of the channels, forming a series of disconnected waterholes. During wet periods, much of the region becomes impassable as those channels overtop their banks and spill out across the floodplains resulting in an explosion of plant and animal life.

The Mithaka people, who are the Traditional Custodians over much of the Queensland part of the region, in collaboration with archaeologists and other researchers, have established a rich cultural landscape stretching back thousands of years at the crossroads of a central Australian trade network. To help put these historical and archaeological efforts into their respective environmental contexts, and better understand how the region has changed in response to human activities and climatic shifts, efforts have been made to collect cores for palaeo-environmental study. This presentation will discuss challenges related to working on channel country, particularly those difficulties associated with use of coring devices largely developed for work in peat-dominated wetlands or unconsolidated sub-aqueous sediments on the markedly different sediments of the region. As well as at some extremely promising results that show the arid interior of Australia may be less of a palynological desert than expected, with one of the cores yielding assemblages of remarkable preservation and abundance.

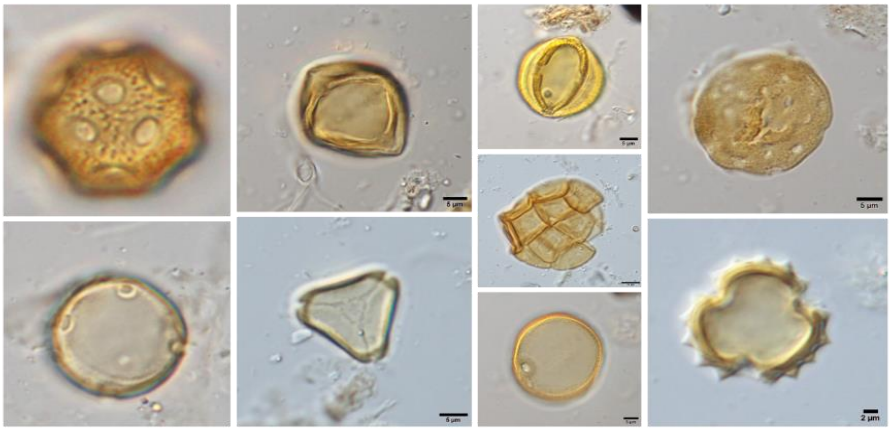

*Figure 1: Selection of pollen recovered from Mithaka Country cores showing excellent preservation*

# Evaluating the application of phytolith analysis in northern Australian environments: results from a plant and soil phytolith reference collection

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The development of phytolith (plant silica) analysis techniques in recent years has provided insight into environmental change in under-studied regions worldwide, including arid zones. However, despite arid conditions dominating 70% of the continent, phytoliths are not yet commonly utilised as a palaeoecological proxy in Australia. Their application to Australian environments has been largely restricted by a lack of modern plant and soil reference material, which is necessary for the interpretation of sedimentary records. The current state of Australian phytolith reference material contains many uncertainties and spatial gaps, and further modern studies are needed to increase the reliability of phytolith analysis in Australian Quaternary Science.

This study reports the results of a modern phytolith reference collection for the Northern Territory, and evaluates the reliability of phytoliths as a proxy for palaeoecological reconstruction in this region. Plant reference material was developed from 94 tree, shrub, and grass species collected from the region. From these results, a detailed, reproducible classification for tropical and arid grassland reconstruction is presented here. This is supported by preliminary results from a soil reference collection for the region, and the taphonomy and deposition of phytoliths into sedimentary records is discussed. Together, this plant and soil reference collection suggests that phytolith assemblages are representative of overlying grassy vegetation communities, and supports the use of fossil phytolith analysis as a tool for palaeoecological reconstruction in northern Australia.

# Using phytoliths to reconstruct vegetation and depositional histories in the Willandra Lakes Region

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While pollen remains the favoured plant fossil for past vegetation reconstructions in Australia, all plant remains available should be studied to provide complementary datasets. One such proxy, are phytoliths ('plant stones') which are robust microscopic plant silica opals (usually ~ 1–100 µm). Rather than a regional signal, phytoliths represent local biocultural vegetation dynamics in palaeoenvironmental assemblages or in situ decay of plant material introduced by people in archaeological assemblages. Phytoliths not only provide vegetation histories, but also depositional histories complementary to archaeological, geochronological and geomorphological data. Without considering phytoliths, especially when other plant remains are absent, our interpretations of past vegetation dynamics in arid Australia will remain poorly understood.

The Willandra Lakes Region World Heritage Area (WLRWHA), home to the Barkandji/Paakantyi, Ngiyampaa and Mutthi Mutthi Traditional Owners in semi-arid Australia, is one location where no palaeovegetation studies have been undertaken. Here we present preliminary results, primarily from geogenic contexts, to provide integrated vegetation and depositional histories for the WLRWHA. Phytoliths frequently preserve well, however grass phytolith preservation varies in terms of reworking, dissolution and winnowing, which relates to aeolian activities. Nevertheless, results suggest that woodlands remained a significant vegetation community throughout time. Results are integrated with new geochronological and geomorphological research, demonstrating the merits of phytolith applications in semi-arid Australia.

# Applications of palynology to the history and restoration of the World Heritage listed Budj Bim landscape in SE Australia

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Budj Bim is the landscape of the native Gunditjmara people that has been added recently to the UNESCO World Heritage list as a remarkably complex cultural and socio-economic lifestyle system within a country that was thought to have been inhabited almost entirely by nomadic hunter-gatherers. The system is considered to have been modified on the Mt Eccles volcanic lava flow to provide connectivity between all the wetlands within the landscape for the purpose of eel aquaculture. This involved the construction and maintenance of numerous channels, weirs and fish traps to control lake levels and stream flow in order to manage, trap, harvest and store short-finned eels. Archaeological attention has focused on the distribution and operation of fish traps and associated collections of stone circles, considered villages, but the system effectively went into disrepair when the Gunditjmara were brutally disconnected from their land with the arrival of Europeans about 200 years ago. Pollen and associated analyses are being employed to provide a picture of changing environments that can inform on the history and timing of Aboriginal occupation and likely activities since their arrival in the region around 45,000 years ago and to contribute to the re-establishment of conditions that will allow the revival of eel aquaculture. Geological dating of the basalt flow indicates that the landscape was formed about 10,000 years before human arrival, a quite unusual situation but one that supports Aboriginal creation stories. The lava flow emanated from proto-Lake Surprise, the site of our major study that provides a very detailed palynological record from 30,000 BP, presumably after cessation of volcanic activity, to present. Major insights are provided into the degree of landscape change between extremes of the last glacial cycle and the most likely time and environmental conditions for eel-farming to have become established.

# Causes of formation of the dune fields of K'gari, South East Queensland, Australia; the roles of sea-level change and climate.

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K'gari is the world's largest sand island and contains extensive series of coastal dune fields. These dune fields are dominated by parabolic dunes up to 200 m high and 11 km long and transgressive sand waves are also extensive. The dunes divide into older Pleistocene sequences which are heavily dissected by fluvial erosion and a Holocene dune sequence that comprises sharp ridged dunes with no internal drainage. While the oldest aeolian deposits on the island are about 1 Ma in age the oldest geomorphic dune sequence yielded a minimum age of c. 340 kyr. The most extensive dune sequences on the island yield ages of 180-200 ka (MIS7). The largest Holocene dune sequences were emplaced after about 8.5 ka with younger sequences emplaced at ca. 4 ka; ca. 1.5 ka; and < 0.5 ka. All the major dune sequences were emplaced during intermediate to high sea-levels with sand arriving on K'gari when coastlines approached their modern positions. All dunes are aligned with modern wind and wave fields. Our evidence strongly supports the Cooper-Thom hypothesis of dune formation at the end of marine transgressions. On shorter time scales, cyclones and other coastal storms reactivate the dune field and we hypothesise that coastal erosion is strongly associated with these events. In contrast we find little evidence for active dunes during glacial times and find no support for aridity driven dune activation. We argue that this part of the Queensland coast remained relatively humid through glacial periods because of its position on the northern limb of the sub-tropical anti-cyclonic belt, which has helped maintain moist onshore SE winds through the mid- to late Pleistocene.

# The late Holocene environmental history of Deepwater Lake, K'gari, south-east Queensland

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K'gari (known for most of its colonial history as Fraser Island) is the largest sand island on Earth. The globally unique and numerous freshwater lakes on K'gari are fundamental to the island's World Heritage listing. The lakes are highly significant to the Butchulla Traditional Owners. They also underpin the region's economy, with > 350,000 visitors/year to Boorangoora (Lake McKenzie) alone. Most K'gari lakes are formed in dune depressions, where an impermeable or semi-impermeable layer of organic and inorganic detritus forms the lake basin. Many lakes are vulnerable to drying as they are "perched" above the regional groundwater aquifer(s). Understanding the history of these lakes and their resilience to environmental change is essential for developing management strategies.

Deepwater Lake is a rare groundwater window lake on K'gari, as indicated by oxygen and hydrogen isotope analyses of contemporary lake waters. However, in contrast to similar window lakes, Deepwater Lake has experienced recent lake level lowering, hypothesised to have resulted in the localised extirpation of an endangered fish (*Pseudomugil mellis*; honey blue-eye).

The sediments of Deepwater Lake have a basal age of approximately 4000 years, consistent with the late Holocene emplacement of dunes which likely created a stream "barrage" to form the lake. We use C and N concentrations and their isotopes, Itrax XRF data and diatoms to infer the history of Deepwater Lake and its catchment. The early history of the lake, particularly before 3,000 yr BP, is characterised by variability which may be due to the time taken for the dunes to stabilise. The lake's recent history is more stable, with a long-term decline in calcium a key feature. This, in turn, has resulted in increased acidity in the lake through time. There is no evidence that the lake dried in the last few thousand years, placing recent hydrological changes in context.

# The influence of changing sea level and hydroclimate on the Mungalla Coastal Wetlands in the Wet Tropics of Queensland

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Wetlands in the Great Barrier Reef Catchment (GBRC) provide vital services such as habitats for fish, birds and other wildlife in addition to improving water quality by trapping nutrients, sediment and pollution. However, they are under increasing pressure from changes in both land use and climate. To alleviate this and help to manage these wetlands the Queensland Government has been monitoring wetlands in the GBRC, now under the Reef 2050 Long-Term Sustainability Plan. To be successful it is important to have the fullest understanding of the long-term drivers of wetland by examining responses to major changes in environment such as hydroclimate or sea level change, especially in coastal wetlands. Here we report on the results from a more than 7,000-year sediment core from Mungalla Station, on the lands of the Nywaigi people, near Ingham, Queensland. Using pollen, charcoal and geochemical tools we demonstrate the influence of changing sea levels and hydroclimate during the Holocene on the condition of the wetland and the influence of land use changes and invasive species. We reflect on how this information may be useful when considering future management of these wetland systems given sea level rise and the current and likely future states of these wetlands.

# Complexity in space and time: A multi-core, multi-proxy history of Eighteen Mile Swamp, Minjerribah

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Eighteen Mile Swamp is a freshwater, 'back-barrier', wallum peatland on Minjerribah's (North Stradbroke Island's) eastern coast, shielded from the sea by coastal dunes. It is typically covered by dense vegetation sustained by low-nutrient, acidic groundwater form both diffuse input along its western fringe and a lake outflow stream. A 2018 fire cleared this cover, enabling us to gather ten sediment cores. In the site's early history, fine mud sediment built up before abruptly shifting to peat. Some cores showed irregular water-filled gaps in the sediment, ranging from 10-50 cm thick. Chronologies revealed the wetland as young, but spatially variable, with its basal age in cores ranging from 1095-1760 BP and the transition from mud to peat sediments 335-1030 BP at depths below ground varying from 3-5 m. Sediment accumulation was rapid giving high core resolution of approximately 1 - 2 years/cm. Multiple proxies indicate that the mud strata are estuarine and derived from mainland river sources. Yet several periods of acidic freshwater dominance within these strata, linked to periods of high rainfall, suggest intermittent estuary closures forming temporary ecosystems known as intermittently closed and open lakes and lagoons (ICOLLs), that were freshened by influx of groundwater. Pollen assemblages and an absence of diatoms in the top 2.5 m of peat suggest a transition around 200 BP from an open freshwater wetland to the vegetated peatland of today, possibly due to a plant mat growing over open water and forming the water filled voids within the sediments. Multiple cores and a ground penetrating radar cross section underscores this site's spatially variable history, with transition from estuary to peat swamp occurring earlier in the south than the north. Forecast sea level rise threatens this wetland in its current guise, and the environmental values it supports.

# Demise of the *Araucaria* scrubs: a pollen record of European transformation of Moreton Bay hinterlands

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Late Quaternary vegetation changes in subtropical eastern Australia have been a focus of work in the last two decades, exploiting well-watered lakes and swamps in the sand islands of Minjerribah and K'gari. A number of records now document vegetation responses to cooling and warming episodes over the last 40 ka, as well as Aboriginal fire management practices over extended periods. However, vegetation records on the mainland are virtually unavailable so that even the pre-European landscape is not well described. Here, we present a pollen record from a shallow marine core in pro-delta sediments of the Brisbane River. Fluvial erosion of pollen and the spectra themselves suggest a high proportion of grains were delivered from riparian areas of the Brisbane River Basin. Around 500 years ago the riparian gorge supported *Araucaria* scrubs: a rainforest of *Araucaria*-dominated vine thicket with *Eucalytpus* and *Melaleuca* lining the banks in drier areas. The sedimentation rate increases rapidly after ~1870 AD and *Araucaria* scrub communities decline in response to intense logging of *Araucaria* and other prize timber trees. The expansion of commercial forestry is clearly evident as an increase of exotic pine after 1960 AD. These changes are in accord with historical and documentary evidence for vegetation changes in the lower and middle Brisbane River valley.

# Australian linear dune growth during glacial-interglacial cycles

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Affiliation/s

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Linear dunes cover over a third of the Australian continent. Their presence, orientation, shape, and size are indicative of the sediment supply and climate during their growth. This makes them an important proxy for past environmental conditions, however past research is divided on what they imply about glacial-interglacial cycles. On one hand, some research has suggested that linear dune activity is predominantly limited to glacial periods—due to reduced precipitation and woody vegetation cover promoting aeolian sediment transport—and therefore dune orientation manifests from a glacial wind climate signature distinct from contemporary wind climate. On the other, some research synthesising sediment ages from linear dunes across Australia has instead suggested that there is no clear glacial dune-building phase. Here we contribute to this debate using a case study of the Great Victoria Desert which suggests that dune-building and precipitation may be correlated in the desert fire regime. We combine this with a comparison of measured orientations of all linear dunes in Australia and those predicted by a suite of contemporary and paleo climate general circulation models. Together these results show there are myriad local and non-local climate controls on dune-field development across the continent. We suggest that continental-scale glacial-interglacial cycles are not the predominant control on—and cannot be inferred from—linear dune properties everywhere in Australia.

# Quaternary landscape and soil processes: incorporating dynamic landsurface processes into conceptual models of soil evolution

Almond, Peter1; Eger, André2, Burge, Olivia2; Larsen, Isaac3; Barrows, Tim4

1 Lincoln University; 2 Manaaki Whenua-Landcare Research; 3University of Massachusetts; 4University of New South Wales.

Semi-periodic climate-related events in the Quaternary, in concert with stochastic tectonic events have generated age sequences of landforms amenable to a substitution of space-for-time approach to investigating long-lived natural phenomena. In soil science, age sequences of landforms such as moraines, outwash terraces, marine terraces and dunes have been used to construct soil chronosequences from which important soil biogeochemical processes and pathways may be deduced. Soil chronosequences exploit the opportunity to characterise soil and ecosystem properties at different points along what is assumed to be a singular evolutionary sequence where the age of the landform represents the age of the soil. The latter assumption is sound so long as erosion or deposition are negligible. Despite the important lessons learnt from such sequences, the often-idealised nature of soil chronosequences places caveats on how they may be extrapolated. On the west coast of the South Island of Aotearoa-NZ soil chronosequences have demonstrated important transformations in phosphorus (P) amounts and forms that occur through time and how ecosystem function is tightly coupled to these changes. However, the dominant part of the landscape comprises landforms undergoing slow or rapid change from erosion or sediment deposition. We hypothesis that these effects lead to a rejuvenation of soils and associated ecosystems by incorporating fresh minerals into soils rapidly impoverished by strong leaching under acid conditions. Focussing on P, we demonstrate in systems of loess additions to the surface of soils, and fresh mineral material contributions by soil production on hillslopes, ecosystems demonstrate evidence of rejuvenation. However, changes in soil nutrient pools show that rejuvenation is not a simple “winding back of the clock” governed by rates of fresh mineral contributions. Our findings contribute to a better understanding of coupled soil-ecosystem processes on the majority of the earth surface that is characterised by dynamic surface processes.

# Identifying warm climate intervals during the Pleistocene and Holocene

Jasper Knight

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Detecting a change in environmental and climatic conditions is a fundamental aim of much research in the palaeosciences. However, interpretations of wetter/dryer or hotter/cooler conditions can often only be made in a relative and qualitative sense only and a rigorous quantitative basis for such interpretations may be difficult to make from individual records. In addition, these interpretations are founded on the available data, and a single data point may simply reflect spatially or temporally 'averaged' conditions that may have limited interpretive meaning. In addition, a limited number of data points, or where data points may encompass many years/seasons or correspond to regional rather than site-specific conditions (or vice versa) may also limit the reliability of any interpretation. These issues are particularly relevant when using proxy data from the Pleistocene or Holocene, beyond the limits of instrumental records. This study critically considers these issues with respect to identifying warm climate intervals, and their properties, that existed during the Pleistocene and Holocene. Consideration is given to: the role of different proxy data types; problems with spatial/temporal resolution of data points (including dating errors); identifying a 'change' in conditions; dealing with seasonal/interannual vs 'averaged' data; identifying start/end dates of any warm interval; and understanding the meaning of temperature variations in the context of the feedbacks that exist within wider environmental systems. This study makes some recommendations regarding project design and interpretation, including consideration of the sampling strategy of continuous records, and the role of multiproxy data in deriving more accurate palaeotemperature estimates.


# Tuesday 25th June

# Abstracts for poster presentations

# Environmental change during a warmer climate in the recent geological past: mid-Pliocene pollen and charcoal paleoreconstructions from marine cores adjacent to the Wet and Dry Tropics of northeast Australia.

Brownhall, Caroline M[1]; Moss, Patrick T[2]; Webb, Gregory[3]; Welsh, Kevin[4]

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A key research theme of the International Ocean Discovery Program (IODP) is responses of ecosystems to present levels of atmospheric $CO_2$ (ie. >400 ppmv) comparable to those in Earth's past. The mid-Pliocene (~3.3-2.9 Ma) is a relatively recent geological epoch characterized by a 2-3°C increase in global mean temperatures and levels of atmospheric $CO_2$ >400 ppmv. International evidence indicates a global increase in fire frequency during the Pliocene, however fire in Australia during the Cenozoic is poorly understood due to an absence of pre-Quaternary charcoal or pollen records from northern Australia. This research presents the first mid-Pliocene charcoal and high-resolution pollen records from north-eastern Australia obtained from marine sediment cores adjacent to the Wet Tropics (ODP Site 823B) and Dry Tropics (ODP Site 815A) from ODP Leg 133. The data indicate warm-wet climate conditions, complex rainforest and wet sclerophyll forest and increased regional biomass burning between ~3.3 and 3.25 Ma, intensifying during interglacial intervals coeval with sea-level rise. Arecaceae pollen and pteridophyte spores indicate higher representation of rainforest during the mid-Pliocene, fluvial transportation of pollen, intensified precipitation or cyclone activity and terrigenous flux coeval with biomass burning. From ~3.2 Ma, mangrove, grass, saltmarsh and swamp communities developed in both regions related to lower sea levels and exposure of the continental shelf, particularly during glacial intervals, while higher representation of savanna is indicated in the Dry Tropics and lowland swamps in the Wet Tropics. An absence of pollen and micro-charcoal in ODP 823B indicates lower precipitation or topographical barriers on the shelf supported by an increase in carbonate deposition. Similarly, an absence of fire, increased fire-sensitive gymnosperm representation, Asteraceae and grass values between ~3.0 and ~2.95 Ma reflect global trends of cooler temperatures, decreased precipitation, levels of atmospheric $CO_2$ (ie. ~235 ppmv), Northern Hemisphere glaciation and ice sheet expansion in Antarctica.

# Pollen in Australia's arid zone: potentials and problems

Cadd, Haidee[1,2]; Cohen, Tim[1,2]; Jankowski, Nathan[1,2]; Boyd, Kelsey[1,2], Turnbull, Molly[1,2]; Saktura, Wanchese[1,2]

Affiliation/s

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Vegetation reconstructions from Australia's arid zone are rare. This is largely due to the consensus that organic proxies do not preserve in these environments and that pollen preservation will therefore be poor. We will present preliminary palynological results from a series of sites examined from the arid and semi-arid zones of Australia. Sites include sediment cores from a series of presently dry lakes, dune, and cave deposits. Whilst preservation is not always optimal, pollen has been identified in almost all samples analysed from the Kimberly to the Willandra. These records will provide a basis for better understanding past vegetation in Australia's arid zone over the past 50,000 years.

# A comparison of lake and speleothem pollen records from the Southwest Australian Floristic Region

Dickson, Bianca [1]; Sniderman, Kale [1]; Korasidis, Vera [1]; Woodhead, Jon [1]

Affiliation/s

[1] School of Geography, Earth and Atmospheric Sciences, The University of Melbourne, Australia

There are many challenges involved in reconstructing Quaternary paleoclimates and vegetation in Australia, including the Southwest Australian Floristic Region (SWAFR). This region is known to harbour an extraordinarily diverse number of plant species. However, counterintuitively, the conditions in this arid and semi-arid region in Australia are generally not conducive to preserving organic material (including pollen) or for sediment accumulation. As a result, vegetation records from large regions are temporally and spatially infrequent, limiting our understanding of the vegetation history and hence how such a hyper-diverse vegetation evolved. This study compares fossil pollen records generated from the caves with lake records from this region, demonstrating that speleothem palynology produces viable vegetation histories comparable in nature to lacustrine pollen proxy records. Furthermore, this comparison helps elucidate whether the pollen source area influences the taphonomy of pollen recovered from caves, and how similar the vegetation histories recorded between the two types of coeval sites, lakes and caves, are to each other. This study has important implications for the SWAFR as well as regions of the world that do not suit the more traditional palynological approach.

# Southern Aotearoa New Zealand hydroclimate and westerly winds over the last 16,000 years

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Affiliation/s

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To address future changes in hydroclimate across southern Aotearoa New Zealand requires records of past hydrological and climate change that go beyond short-term instrumental records. Climate and hydrology in the region are regulated by the strength and latitudinal position of the Southern Hemisphere westerly winds (SWW). Mid-latitude storm tracks, which follow the wind maximum, hit the barrier of the Te Tiritiri-o-te-moana/Southern Alps causing high amounts of precipitation on the west coast with spill-over into catchments in the east.

We have developed a hydroclimate record using cores from Lake Von, which lies east of Te Tiritiri-o-te-moana/Southern Alps. This record shows changes in the water level at Lake Von over the past 16,000 years that we attribute to SWW changes. There are two broad intervals of lower lake levels 6,000 – 3,000 and 10,000 – 8,000 cal BP that are punctuated by extreme lake lowering events shown by deposition of inorganic silt in the lake depocenter. Relatively higher lake levels occur 8,000 – 6,000 and 13,000 – 12,000 cal BP.

We also compare this hydrological and SWW record from southern Aotearoa New Zealand to others from across the Pacific Basin and find that low lake levels during the early Holocene correspond with weaker SWW across the Pacific basin but there is divergence in the records during the mid-to-late Holocene.

# The updated Indo-Pacific Pollen Database (IPPD): a valuable new asset to the Neotoma Palaeoecological online database

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The Indo-Pacific Pollen Database (IPPD) is the brainchild of the late Professor Geoffrey Hope, who gathered pollen records from across the region to ensure their preservation for future generations of palaeoecologists. This aim is now being fulfilled by integrating the IPPD into the online Neotoma Palaeoecological Database, making this great compilation available for public use. Here we explore the database in depth and suggest directions for future research. The IPPD comprises 226 fossil pollen records, most postdating 20 ka, but some predating 50 ka. However, many of the records contain few samples or have fewer than 5 chronology control points. 83.6% of the records are Australian, with a fairly even distribution between the different Australian geographical regions, the notable exception being Western Australia, represented by 3 records. The records are also well distributed in modern climate space, the largest gap being in drier regions due to preservation issues. Average sedimentation rates counted as years per cm are quite low for many sequences, meaning each cm of sediment represents a fairly low number of years, with 61% of the records having a rate of less than 50 yr/cm. The average rate for the whole IPPD is 60 yr/cm, the highest rate by geographical region occurring in arid Australia. The lowest rates are from the Western Pacific and Maritime SE Asia. Overall, Australia has a higher rate than the rest of the Indo-Pacific region. This could be due to targeting longer records, which tend to have a higher rate, or relatively lower precipitation leading to lower biological activity in the lakes and wetlands that represent the majority of sites. The IPPD offers many exciting research opportunities, such as the examination of human impact on regional vegetation, contrasting first human arrival and colonialization, or the assessing rates of vegetation change.

# Predicting coral rubble risk in the Great Barrier Reef

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As cumulative impacts drive increased coral mortality, there is potential for higher rates of coral rubble generation and persistence. “Too much” rubble on reefs decreases resilience through impeding coral settlement and growth. Identifying which of the 3,800 reefs on the Great Barrier Reef have a high risk of rubble generation is a challenge. We developed statistical models (generalized linear model, random forest, and neural networks) to predict rubble using the GBR10 Benthic Habitat map with 10m resolution. Rubble generation and persistence factors modelled included cumulative Degree Heating Weeks (DHW), mean DHW, crown-of-thorns seastars, cyclone tracks, cyclone wave height, wave height, wave energy density, bottom velocity, surface current, ship tracks, tsunamis, bioregion, and latitude. The regression model had 70% accuracy of predicting rubble with a 28% false positive rate while the machine learning methods had higher accuracy (~90%) and lower false positives detection (~5%). However, to assess whether these tools are accurate enough, we need to consider coral reef rubble modelling from the perspective of coral management decisions. Our results suggest that probability of rubble is likely to increase in future warming scenarios. These models could be used to prioritise areas of monitoring for rubble increases and sites for intervention deployment.

# Unveiling Coastal Hazards: Insights from Erratic Boulders on Niuatoputapu Island (Tonga)

Koehler, Martin[1]; Lau, A.Y. Annie[1]

[1] School of the Environment, The University of Queensland

Erratic boulders found along coastlines serve as silent witnesses to the immense power of natural hazards such as tsunamis and cyclonic storms. Understanding the origin and time of emplacement of these boulders is crucial for assessing the frequency, severity, and location of coastal hazards. This study focuses on 70 carbonate boulders discovered on Niuatoputapu Island in the southwest Pacific, including some believed to have been emplaced by a tsunami in 2009, and some requires further investigations into the mechanisms of their deposition.

While the 2009 Samoa tsunami impacts on Niuatoputapu have been immediately surveyed and presented in Clark et al. (2011), that study focused on mapping the inundation limits of the waves, and the erosional tsunami features observed at the time of survey. The presence of these tsunami boulders remained unknown to the scientific community until now. By evaluating the distribution and characteristics of these boulders, we can gain valuable insights into the size and extent of deposits of previous tsunamis and their post-depositional development, thus enhancing our understanding of coastal hazard dynamics and preservation. Through detailed field surveys, remote sensing techniques, and laboratory analyses, we aim to unravel the complex processes involved in their transportation and deposition. By correlating the boulder distribution with tsunami inundation models and historical accounts, we seek to refine our knowledge of past tsunami events and their impact on coastal landscapes.

The findings from this study have significant implications for coastal hazard assessment and risk management strategies. By incorporating data from erratic boulders and other tsunami deposits into hazard models, we can improve the accuracy of hazard mapping and evacuation planning efforts. Furthermore, the identification of previously unrecognized extreme event deposits underscores the importance of continued research and monitoring along vulnerable coastlines to enhance resilience to future hazard events.

# Where Are All The Coastal Boulders? A Global Research Network Targeting Coastal Boulder Deposits

Lau, A.Y .Annie[1]; Engel, Max[2]; Cox, Ronadh[3]; Mori, Nobuhito[4]; Berke, Melissa A.[5]; Guannel, Gregory[6]; Kennedy, Andrew B.[5]

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Intertidal and supratidal coastal boulder deposits (CBD) result from extreme marine inundation on rocky shores. They are important for understanding long-term coastal wave hazards (both storm and tsunami), have potential predictive value for future events, and support assessment and planning for rocky coasts. However, there are at least two main obstacles to deeper understanding of CBD transport and applications: a lack of data on CBD worldwide, and discrepant approaches that lead to difficulties in comparing data from different sites. Building community and interaction among CBD researchers, and awareness of CBD as research targets, can help grow our knowledge and our ability to tackle these questions.

ISROC—Inundation Signatures on Rocky Coastlines—is an NSF-funded Research Coordination Network started in 2021 to define the CBD problem chain and identify research gaps by developing a broad and diverse network of researchers. Our goals are to extend the community of researchers to include underrepresented groups; to facilitate the development of standards and best practices for gathering and archiving CBD data; to develop cyberinfrastructure for uploading, visualizing, and analyzing data; and to train the next generation of CBD researchers. Understanding CBD and using them as a tool to reconstruct coastal inundation history and extreme climatological states is a prime example of convergence research that one discipline cannot solve. Thus, we create opportunities for cross-disciplinary collaboration and exchange. The ISROC network includes geologists, geographers, oceanographers, engineers, hydrodynamicists, geophysicists, climatologists, and paleoclimatologists. ISROC activities include meetings, student training, exchanges; sessions at major conferences in geoscience and coastal engineering; consolidation of survey/mapping approaches; and building a global database, including user-friendly, fully accessible online data archiving. Understanding past inundation and how CBD form and evolve will help quantify present-day risk and provide guidance for what to expect from future climate and sea levels.

# Last Glacial Maximum and deglacial brGDGT-based paleotemperature reconstruction from a subtropical wetland from Australia

Macalalad, Joan [1]; Welsh, Kevin [1]; Hofmann, Harald [1]; Jacobsen, Geraldine [2]; Ni, Zhenyu [3]; Zhang, Enlou [3]

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Future projections of climate change in the subtropics suggest warming and drying, while evidence from warm periods in the past show evidence increases in subtropical precipitation. Eastern Australia is also subject to interannual hydroclimate drivers such as ENSO and in recent years, has experienced extreme flooding and droughts. To understand how the changes to the mean global conditions may affect sensitive environments such as the wetlands in this area, baseline records of climatic change, including mean temperatures, for example, since and during the Last Glacial Maximum (LGM) are vital. Several paleo records exist from the coastal sand islands of Minjerribah (North Stradbroke Island) and K'gari (Fraser Island), Southeast Queensland). However, these records appear to show divergent responses to climate change. Where the Minjerribah records indicate a positive moisture balance, while the K'gari records show hiatuses that are indicative of drought conditions.

Presented here is a paleoclimate reconstruction spanning the Last Glacial Maximum to Holocene, utilising glycerol dialkyl glycerol tetraethers (GDGT), for Broutha Waterhole, a subtropical perched wetland in the Cooloola Sand Mass, Queensland Australia, located between Minjerribah and K'gari. The continuous GDGT-based paleotemperature reconstruction features two temperature minima during the LGM with a maximum cooling of 4.3 °C, which is very close to the paleotemperature recorded from K'gari. A progressively warming temperature during the deglacial is interrupted by a rapid cooling coincident with the Antarctic Cold Reversal (ACR) followed by a stable warm Holocene trend. This study provides a continuous paleo proxy record that aims to address the paucity of continuous terrestrial archives in the subtropics and ultimately, contribute a new quantitative paleoclimate to help bridge the knowledge gap between the tropical north and temperate south.

# Drivers of Early Pleistocene glacial-interglacial cycles using speleothems and ocean sediments

Ulasi, Ngozi[1*]; Drysdale, Russell[1]; Woodhead, Jon[1]; Pollard, Timothy[1]; Hodell, David[2]; Isola, Ilaria[3]; Regattieri, Eleonora[4]; Zanchetta, Giovanni[5]

Affiliation/s

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During the Quaternary Period, Earth's climate oscillated between glacial and interglacial states, comprising about 50 cycles. The low-amplitude, 40-kyr pendulum of this sequence 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, and a more pronounced saw-tooth pattern to the cycles emerged. The cause of this transition remains unresolved. Several hypotheses have been proposed for the 40-kyr ice ages. Recent work suggests that insolation intensity in the Northern Hemisphere (NH) high latitudes, rather than obliquity, triggered the termination of each glaciation but determining the most important orbital parameter remains a problem due to uncertainties over the precise timing of these events. North Atlantic marine-sediment records possess the best-preserved imprints of these terminations, but precise dating is lacking.

In this talk, we will present the first results of research that aims to link accurately and precisely dated speleothem records from Corchia Cave (Italy) from the interval 0.98 to 1.30 Ma to a high-resolution ocean-sediment record from North Atlantic site U1385 to understand what drove ice-age terminations of the 40-kyr world. This is being achieved through three objectives. Objective 1 develops radiometrically dated speleothem time series of past rainfall and temperature that can be synchronized to the ocean record. Objective 2 develops a series of termination timings and durations based on the new radiometric ocean-core chronology. Objective 3 compares the radiometrically constrained timing and duration of each termination to insolation metrics to unravel the most important pacing orbital parameter and/or insolation metric through the MPT. This research aims to provide new insights into astronomical forcing of Early Pleistocene terminations through the construction of a radiometrically constrained ocean-sediment record of Northern Hemisphere ice-sheet history.

# Local to global sea-level changes recorded by mangrove sediment archives in the equatorial Pacific Ocean

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Affiliation/s

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Mangrove sediment is an important archive of Late Holocene sea-level change. Such archives are limited to places where sediment accommodation space is being generated, i.e., where relative sea is rising as a result of vertical land motion and/or ocean volume and mass change. In the equatorial Pacific Ocean, relative sea level was 1–2 metres higher than present during the Mid Holocene and has been falling until recent pre-industrial times, resulting in limited mangrove sea-level reconstructions. However, there are some locations experiencing subsidence that have generated sufficient accommodation space for mangrove sediment archives to accumulate over the last 5,000 years. We present five new relative sea-level reconstructions from radiocarbon-dated mangrove sediments from the islands of Pohnpei, Kosrae (Federated States of Micronesia), Upolu (Samoa), and Tutuila (American Samoa) that indicate rapid and ongoing island subsidence at rates >1 mm/yr. The rate of vertical land motion indicated by our mangrove reconstructions provides empirical estimates to test hypotheses about a) the lifespan of ocean islands (as GNSS provided rates are limited to the 21$^{st}$ century), and b) processes of post-seismic visco-elastic relaxation of the Earth's crust. Our new reconstructions are added to a global database which, when analysed using a spatial-temporal-empirical-hierarchical model, provides an estimate of 'global' mean sea level variability over the Common Era.

# New insights on the internal structure of inter-reef *Halimeda* bioherms, northern Great Barrier Reef

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*Halimeda* accumulations form some of the largest connected inter-reef biogenic structures in the Great Barrier Reef covering >6000 km$^2$ of the continental shelf - an expanse surpassing that of the adjacent coral reefs at equivalent latitudes. Previous studies have shown the shapes and internal structure of these accumulations, underscoring their significant contribution to the neritic carbonate factory throughout the Holocene. However, a comprehensive understanding of their formation and development has been hindered by the absence of densely spaced core samples that target bioherm morphologies.

This study presents new data from the 2022 RV Investigator voyage V07 “Halimeda bioherms: Origins, function and fate in the northern Great Barrier Reef (HALO)” collected 0.5 m resolution multibeam bathymetry to over 3 inter-reef sites (Ribbon Reef, Cormorant Reef and Tijou Reef) to target bioherm morphotypes with 42 densely spaced vibrocores. A total of 242 m of cores have been scanned with CT, 50 m of core logged to show a variety of facies from estuary to coral rich. Twenty-three radiocarbon dates range from 12 kys to 37 kys and are consistent with previous studies. Initial observations revealed further facies complexity than previously thought and a latitudinal variation from south to north. This newfound dataset promises to enhance our comprehension of *Halimeda* bioherm dynamics, shedding light on their intricate morphological variations and geographical influences.


# Wednesday 26th June

# Abstracts for oral presentations

# The Origin of the Central Great Barrier Reef

Dunbar, Gavin[1]; Abram, Nerilie[2]; Albot, Olya[1]; Beltran, Catherine[3]; Bostock, Helen[4]; Duncan, Bella[1]; Naeher, Sebastian[5]; Seki, Osamu[6]; Stevenson, Lottie[1]; Waldran, Nicole[1]; Webster, Jody[7].

Affiliation/s

[1]Victoria University of Wellington; [2]The Australian National University; [3]University of Otago; [4]The University of Queensland; [5]GNS Science Ltd; [6]Hokkaido University; [7]The University of Sydney

The Great Barrier Reef (GBR) is one of the wonders of the natural world. However, the environmental circumstances under which it first developed are still unclear. Data from ODP Site 822 addresses this issue (Fig.1 inset). Our analyses include XRD, XRF, $\delta^{18}O$ and alkenone unsaturation. Using $\delta^{18}O$ and paleomagnetic stratigraphy to provide chronology, our data show a stepwise change in sedimentation occurs between 900 and 700 ka (Fig.1A), consistent with a switch from a prograding to an aggrading continental margin evident in seismic profiles. Alkenone-derived sea surface temperature (SST) shows a minimum at 800 ka but at no point drops below the threshold for coral growth (Fig.1B) and appears not to play a direct role in the GBR's origin. Terrigenous sediment accumulation (Ti & $CaCO_3$) is relatively high and in-phase with sea level prior to 800 ka. At 800 ka an abrupt decrease in terrigenous sediment accumulation occurs (Fig.1C – 1). Simultaneously, a step change in Al/Ti is indicative of a change in terrigenous sediment source, size, weathering regime or some combination thereof. Changes in the accumulation of reef coral and associated material are indicated by increasing Sr/Ca (from Sr-rich aragonite) and high-Mg calcite (HMC). Sr/Ca and HMC vary out-of-phase prior to 800 ka but are in phase thereafter. A notable increase in Sr/Ca at 700 ka indicates a change in biogenic carbonate response to sea level. We suggest the 700 ka highstand (2) shows the same sedimentary characteristics associated with growth of a barrier reef evident in the Holocene. We propose a change in climate greatly reduced the flux of terrigenous sediment to the continental margin at 800 ka, allowing nascent coral communities to expand and aggrade to form the Great Barrier Reef as we know it from 700 ka.

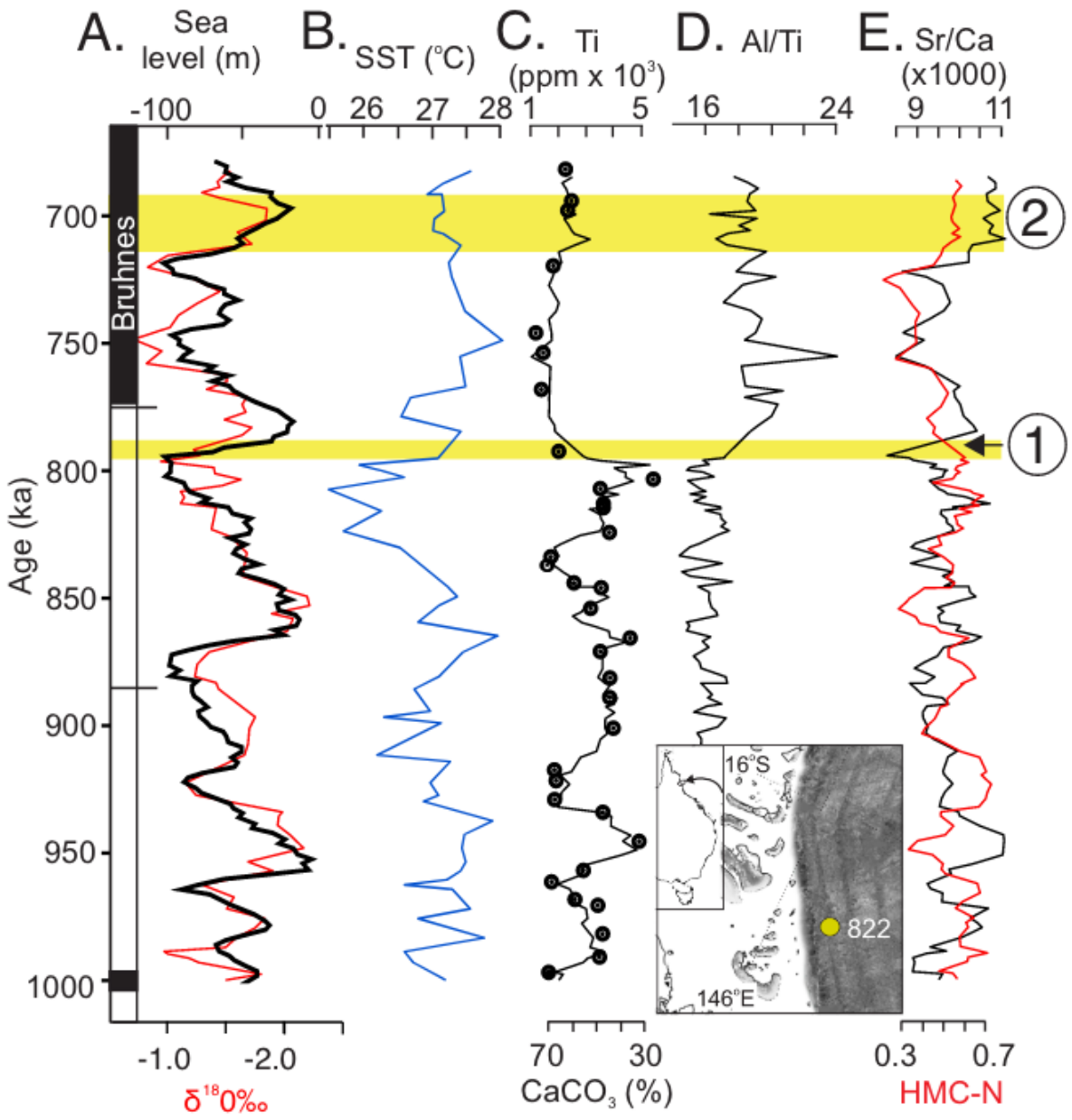


*Figure 1. Sedimentation patterns at ODP Site 822 from 1000 to 650 ka.*

# Coral reef response since the Mid Pleistocene Climate Transition from the NW shelf of Australia

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Affiliation/s

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Quaternary coral reef science has limited understanding of coral reef response to the Mid Pleistocene Climate Transition (MPT) (ca. 0.8–0.6 Ma) that triggered the Earth's transition into a dry, arid climate and eventually into a period of glacial-interglacial cycles. During this period many of the extant large reef systems initiated, for example barrier reefs in Pacific atolls, the Great Barrier Reef. However, data availability is low.

North and South Scott Reefs are isolated carbonate platforms on the North West Shelf of Australia that have outpaced subsidence and oceanographic stressors intermittently since the Miocene. Carbonate platform evolution from precursor isolated carbonate buildups ca. 20 Ma to present have been characterised using seismic stratigraphy and industry well log data, however, high resolution reconstructions of environmental processes controlling coral reef growth cycles have not been determined prior to the Holocene. Lithologic and chrono-stratigraphic interpretations of 4 fossil coral reef boreholes extending to 200 m below sea floor provide new insights into the sensitivities of coral reef response to regional (i.e., tectonics, oceanographic) and global (i.e., climate, eustacy) environmental forcing conditions at millennial scale resolution since the MPT. Depositional facies and paleoenvironmental reconstructions are made based on: detailed logging, petrologic, mineralogic and sedimentary lithofacies analysis of 4 boreholes located on the windward and leeward reef crests of north and south Scott Reef. Coralgal assemblages and other reef biota (e.g., foraminifera) are identified that constrain paleowater depths and more precise paleoenvironmental indicators. New radiometric dating based on sample selection from hyperspectral and neutron scattering data are presented.

We aim to evaluate coral reef framework sequences and lithologies spatially and chronologically across both reefs, including vertical growth, karstification and ecological processes within the uppermost 200 m of sediment core in response to increased sea level periodicity post MPT, as the Earth transitioned from 41 kyr obliquity driven sea level cycles to a 100 kyr eccentricity driven orbital cycles. We recognise distinct reef growth cycles within lithologic and chrono-stratigraphic units that correspond to global high sea levels within Marine Isotope Stages (MIS) 1 (Holocene), 5, 7, 8, 11, 13. Each reef growth cycle established on the drowned North and South platforms during the deglacial and interglacial sea levels. Hiatuses in reef growth are observed through identification of paleosol horizons in the core that signals subaerial exposure events during glacial (low sea level) periods. Significant variations in elevation, subsidence histories, paleo-coralgal communities and

geomorphological features are observed between the north and south reef, as well as spatially across each reef. Sequences of coral reef growth kept pace with deglacial sea level rise owing to favourable environmental and oceanographic conditions that allowed the cyclic re-establishment of shallow, moderate and deep-water coral reef development across both platforms since the MPT.

A comprehensive review of comparable MPT-triggered reef growth cycles is made between Ribbon Reef 5 on the NE margin of Australia that exposes some significant variations in reef response to eustatic (subsidence and sea level) and environmental controls, including: proximity to land, position along the continental shelf, terrigenous sediment influx, seabed geomorphology, ocean currents and nearby sites for coral larvae recruitment. Integration and analysis of two newly acquired and two undescribed fossil coral reef cores provides a unique insight into the Quaternary history of a key site along the NWS, demonstrating how fossils can be used to reconstruct Earth history to answer broader questions in the bio and geological sciences with respect to coral reef ecological responses to climate change.

# Quaternary Evolution of the East Australian Current

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[1]University of Queensland

The East Australian Current (EAC) is a narrow, fast flowing western boundary current which courses south along the east coast of Australia. The EAC transfers warm, salty, low nutrient surface waters from the tropics to higher latitudes, influencing marine ecosystems, such as the Great Barrier Reef (GBR), and the climate of Australia's east coast. Isotopic and foraminiferal assemblages provide evidence for a reduced EAC during the last glacial. However, little is known about the longer-term evolution of the EAC during the Quaternary.

We undertook a multiproxy study of marine sediment core ODP 1195A, situated on the relatively shallow Marion Plateau (~420 m water depth), offshore the Swain Reefs within the Southern GBR. Biostratigraphic datums indicate that the top 24 m of the core is 2 million years old. Whilst a detailed chronology could not be constructed due to diagenetic alternation of the stable oxygen isotope data, Glacial/Interglacial cycles were interpreted based on cyclical changes in grainsize (sortable silt) and XRF elemental data (Fe, Al, Si). These proxies indicate the eastward migration of the EAC with glacial sea level cycles. Over the longer-term, several sedimentological changes are observed within the core, likely related to changes in the amplitude of sea level fluctuations, the intensification of Monsoonal activity across Queensland and the establishment of the GBR less than 1 Ma.

Despite 30 years of research, questions remain regarding why the Southern GBR is so young, and what paleo-environmental conditions triggered the initiation of the Swain Reefs. Interestingly, the presence of coral fragments in the core sediments, corroborated by mineralogy data, offers evidence for the existence of proto mesophotic reefs on the Marion Plateau as early as ~1.4 Ma, significantly predating the establishment of the GBR.

# Do palaeoenvironmental archives have uniform trace element distributions in contemporaneous increments? Investigating giant clam (*Tridacna*) shells through LIBS

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Ultra-high resolution palaeo-environmental proxies from archaeological archives provide us with a window into ancient times. As one of the most common and well-developed archives, bivalve shells play a very important role in connecting palaeo-environment with ancient human behaviours. Sr/Ca and Mg/Ca ratios in bivalve shells are often employed as proxies for reconstructing palaeoenvironmental parameters such as sea surface temperature. However, we still lack a basic understanding of whether bivalve shells have evenly distributed trace element concentrations in contemporaneous growth increments.

In this study, we applied Laser Induced Breakdown Spectroscopy (LIBS) on *Tridacna* shells. LIBS employs a fast laser and low energy pulse (1–2 mJ) which enables rapid analysis that is less destructive than other geochemical techniques. This makes LIBS well-suited for scanning large areas in a rapid pre-scanning step prior to further geochemical analyses. It is also less destructive to archaeological samples. As one of the biggest and fastest-growing bivalves, *Tridacna* can provide wide and clear contemporaneous daily increments for analysis.

Our scanning results show that Sr/Ca distribution in the contemporaneous increments is unified in both the inner and the outer shell layers. However, the Mg/Ca distribution shows uneven patterns in the outer shell layer, which indicates the need for caution in analysing the outer shell when undertaking quantitative Mg/Ca analyses.

# Oxygen isotope variations in *Conomurex luhuanus*: A new high-resolution paleoclimate archive from the Great Barrier Reef

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*Conomurex luhuanus* is an intertidal short-lived marine gastropod shell. This species is one of the most exploited species from Holocene coastal archaeological shell middens in the Great Barrier Reef and other Pacific countries. Therefore, analyzing $\delta^{18}O_{shell}$ on shells provides a wealth of information about paleoclimate and the seasonality of shellfish gathering of the prehistorical people. Before studying archaeological assemblages, it is essential to apply sclerochronological techniques on local modern *Conomurex luhuanus* to understand whether and how reliable the shells can encode local environmental factors, in particular sea surface temperature (SST). In this research, we employ sclerochronology techniques to analyse oxygen isotopes in modern *Conomurex luhuanus* shells to test the efficacy of the species in recording environmental factors. Measured $\delta^{18}O_{shell}$ ranged between -0.4 and -1.5 ‰ (VPDB) in modern samples. Our results show that this species can reliably record SST in equilibrium with the surrounding environment at daily resolution. We will use the same technique on archaeological shells to determine the seasonal variability of the shellfishing behaviour of the Traditional Owners at Jiigurru (Lizard Island). This research will provide the first scientific evidence of seasonal-resolution human landscape use at Jiigurru. Considering the deep-time archaeology and continuing connection to Country of the Traditional Owners at Jiigurru, such information helps to inform future sustainable management practices of the fragile GBR system that foregrounds traditional Indigenous shellfish management.

# Rocky coastline bio-mediated carbonate deposits: Quaternary archive, modern environmental stress indicator or both?

Matt Forbes*[1,6], Gavin Rishworth[2], Graham.J.C. Underwood[3], Andrew Cooper[4], Tom Garner[4], Natalie Hicks[3], Carla Dodd[2], Terry McGenity[3], Alan Smith[5], Hayley Cawthra[2], Janine Adams[2], David Clark[3].

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Rocky coastlines that are interconnected with discharges of mineralised groundwater seeps, can see the development of carbonate formations (tufa) driven by microbial and microalgal biofilm fixation. These formations can exist in a number of sub-environments in the high intertidal and supratidal zone and are affected by occasional storms and the effects of sea spray. Their contemporary occurrence depends on the partial exclusion of competing organisms which, in turn, is linked to this supratidal setting: where alternations between terrestrial and marine conditions create extreme conditions in which microbial precipitation is facilitated. The occurrence of such supratidal microbialite tufa on high-energy open, rocky coasts have been increasingly recognised worldwide, with particular well researched locations occurring at similar settings along stretches of South African, British and Australian shorelines. Individual occurrences at these sites are typically of restricted lateral extent (<100 m alongshore) and are associated with groundwater outlets but collectively, their known distribution covers many hundreds of kilometres of rocky coastline.

Rocky coast tufa deposits are proposed as potential Quaternary analogues for Precambrian microbialites. The currently active Quaternary formations are thought to be predominantly of Holocene age and given their position on the current immediate shoreline are of an age related to current sea-level. However, non-active forms have been observed at similar and higher elevations, where groundwater expressions no longer occur. Their occurrence at previous lower shoreline elevations that are now inundated has also been investigated. Thus, rocky coast tufa can represent both transgressive and regressive settings.

This paper presents an overview of the work that the international EPStromNet research team has been undertaking since 2020. The team has undertaken a systematic investigation of coastal microbialites located in Western Australia, South Africa and Ireland, to understand their similarities and functioning, in terms of geology, microbial composition, water quality, and physico-chemistry. Determining their ability to provide a Quaternary record is a key component of this work, with challenges associated accurately placing these open carbonate systems, both current and extant, in a robust chronological framework. This paper will use

components of the above research to debate whether these systems are Quaternary records of value, environmental stress indicators, or ultimately both.

# New Common Era sea-level reconstructions from southeastern Australia

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Since around the 1860s, global sea level has been rising – and accelerating – at an 'unprecedented' rate. This rise has been recorded by tide gauges and organic coastal sediment archives worldwide, and advances to understand how this rise manifests at regional to local scales are underway, particularly in the North Atlantic region. In Australia, the tide gauge record is short (mostly since 1950) and there are a limited number of sedimentary records that provide information on sea-level change. The records that do exist indicate the rate of rise in southeastern Australian exceeds the global average in the 20$^{th}$ century (e.g., Williams et al., 2023). We present two new sea-level reconstructions from southeastern Australia developed from saltmarsh foraminifera at King Island (Tasmania) and Venus Bay (Victoria). We develop chronologies for both sediment records using radiocarbon and lead isotopes. The fossil foraminifera assemblages at both sites indicate local sea-level rise over the past ~150 years. Spatial-temporal modelling of geological sea-level data highlights the contribution of local, regional, and global processes through space and time. This work fits into a larger effort to build a network of sedimentary sea-level records to determine a sea-level 'budget' in southeastern Australia.

# Using peat to reconstruct Holocene climate change at Motu Ihupuku/Campbell Island (52°S)

Greer Gilmer[1]; Marcus Vandergoes[1]; Chris Moy[2]

Affiliation/s

[1] GNS Science; [2] University of Otago

In the vast expanse of Southern Ocean, subantarctic islands provide a variety of environments from which paleoclimate records can be collected. As well as providing a record of local climate change, these records can be used to reconstruct ocean and atmosphere links between Antarctica and the middle latitudes.

The climate on subantarctic Motu Ihupuku/Campbell Island (52°S) is strongly coupled to the prevailing Southern Hemisphere westerly winds (SWW) and peatlands that have been accumulating on the island since the Late Glacial are archives of past climate and SWW.

Here we present an initial dataset of elemental ratios from high-resolution XRF core scanning, and bulk carbon and nitrogen isotopes. We use these proxy analyses to interpret changes in SWW, precipitation, vegetation, and peat decomposition. This peat record spans the last 16,000 years and is deposited on top of lithogenic material that is characterised by high Ti/inc and %inorganic values. Element ratios associated with marine influence, dust deposition, and redox conditions fluctuate during the Holocene, which we attribute to changes in wind strength and precipitation. This new record is integrated with existing pollen records from Motu Ihupuku/Campbell Island to get an overall picture of environmental change over the Holocene.

# Climatic drivers of deglaciation at two southern Indian Ocean islands during Marine Isotopic Stages 3 and 2

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Affiliation/s

[1] Aix Marseille Université, CNRS, IRD, INRAE, CEREGE, Aix-en-Provence, France; [2] Afromontane Research Unit, Department of Geography, University of the Free State, Bloemfontein, South Africa; [3] Department of Geography, University of South Africa, Pioneer Avenue, Florida, South Africa; [4] Department of Geography and Environmental Science, University of Fort Hare, Alice, South Africa

It is increasingly apparent that variability in deglaciation chronologies of the Southern Hemisphere is important to consider when untangling climatic drivers across the Southern Ocean. We review glacial reconstructions from two southern Indian Ocean Islands, Marion Island (46°S; 37°E) and the Kerguelen Archipelago (49°S; 69°E), with the aim to identify warming periods in Marine Isotopic Stages 3 and 2. We use 91 36Cl cosmic-ray exposure (CRE) ages of glacial landforms from both islands to produce a consolidated chronology which spans from ~63 ka to 17 ka ago. Glacier culminations are interpreted at ~60.6 ka, ~51.4 ka (Marion Island) and at ~42 ka (both islands). CRE ages of bedrock surfaces (~48 ka to ~17 ka) and erratics (~63 ka to ~20 ka) from both islands indicate multiple periods of retreat, interrupted by still stands, throughout MIS 3, MIS 2 and, particularly, the gLGM. We ascribe this deglaciation pattern to the rather chaotic and frequent fluctuations of sea surface temperatures and sea ice extent in, specifically, the western Indian Ocean sector. At Kerguelen, evidence for glacial culminations is also found for the latter end of the gLGM, synchronous to the deglaciation pattern, but evidence of glacial advances is markedly absent on Marion Island. We attribute this to the influence of island topography and physiography on local equilibrium line altitudes. At the peak of the gLGM during sea level low stands and extensive sea-ice, Marion Island would be starved of moisture inputs earlier than the more southern Kerguelen Archipelago with a significantly higher peak. We conclude that deglaciation patterns observed at particular sub-Antarctic islands from ~42 ka can predominantly be attributed to the variability of sea surface temperatures and a potential decrease in precipitation, possibly as a function of extensive sea ice and lower sea levels leading up to the gLGM.

# Deglacial polar Southern Ocean carbon release driven by physical and biological dynamics

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The polar Southern Ocean is deemed as a critical region regulating air-sea gas exchange, with important implications for atmospheric CO2 rises during deglaciations. However, data evidence is sparse to evaluate the respective roles of Southern Ocean physical and biological dynamics in affecting past air-sea CO2 exchange, in part, due to longstanding challenges to obtain carbonate materials for surface condition reconstructions in this region. Here, we circumvent these challenges by constraining polar Southern Ocean surface-water (i.e., preformed) conditions based on paired carbonate ion-phosphate-oxygenation reconstructions of deep waters during the last deglaciation. Our data provide strong evidence for carbon losses from the deep South Pacific to the atmosphere, modulated by nutrient utilization and gas exchange disequilibrium in the polar Southern Ocean, on both orbital and millennial timescales. Moreover, for the first time, our proxy data reveals that physical dynamics involving sea ice retreats dominated CO2 outgassing in the polar Southern Ocean during the early stage of the last deglaciation, highlighting critical roles of non-biological processes in initiating the last glacial termination.

# Paleoenvironmental changes from offshore Cape Darnley, East Antarctica, over the last 500 ka, including super-interglacials MIS 5E and MIS 11

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[1] University of Queensland; [2] Colgate University; [3] Geoscience Australia; [4] University of Tasmania

The Cape Darnley region in East Antarctica has global significance as the third highest sea ice producing region in Antarctica and is one of only four regions that forms the important Antarctic Bottom Water mass. Under future climate scenarios, these systems may be severely disrupted, however, there is evidence that this may have occurred in geological history. Warmer than present intervals (MIS 5e and MIS 11) can be investigated to better understand climatic tipping points using sedimentary records.

In early 2023, a voyage of the RV *Investigator* collected a suite of marine sediment cores from 'Armand Drift', a sediment drift offshore of Cape Darnley. One core, IN2023_V01_KC02, has been dated using diatom biostratigraphy and contains a continuous record of the past 700 ka. Diatoms are siliceous algae that fossilise well and are useful as past sea ice, sea surface temperature and ocean productivity proxies. The diatom assemblage of this sediment core, accompanied by elemental and physical sedimentological data, is currently under study to reconstruct this important region. Preliminary results demonstrate heightened productivity at MIS 5e, although this is much lower at MIS 11.

# Deepwater circulation change in the South China Sea during the last glacial cycle

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The North Pacific is the terminus of global deepwater circulation and holds the largest carbon storage among the oceans. However, understanding Pacific deepwater changes during glacial cycles is difficult because of its corrosive nature and poor carbonate preservation. The South China Sea (SCS) offers an alternative perspective because of better preservation of carbonates and its deep sill at a depth of ~2400 m at Bashi Strait, allowing exchange with Pacific deep water. This study examines how deep circulation proxies work in the SCS by analyzing benthic δ13C and redox elements during the last glacial cycle.

The redox element data shows different changes above and below the ~2400 m sill depth. In the upper deep water, oxygen levels significantly decrease during the MIS 5a-4 transition and gradually decline until MIS 2, which is similar to Pacific records. In the lower deep water, oxygen levels are high during glacials and low during interglacials. This pattern suggests that intensified stratification in the SCS during glacial periods limits low-oxygen water supply from the upper layers.

Both layers show similar $\delta^{13}C$ cyclic changes, the north-south gradient differs. During the last glacial cycle, the lower layer has more positive $\delta^{13}C$ in the south, while the upper layer shows opposite pattern, except during the MIS 2. This observation indicates that deep circulation proxies in the SCS also reflect local changes, such as productivity and vertical mixing, which must be considered when investigating Pacific deep water changes.

This study provides a clearer picture of SCS deepwater circulation changes during the last glacial cycle. Additionally, the findings also emphasize the need to consider local factors when inferring broader oceanographic changes.


# Thursday 27th June

# Abstracts for oral presentations

# Hydroclimate variability in Australia through the last 2000 years: a critical review of progress and priorities

Tyler, Jonathan [1,2]

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High quality, replicable palaeoclimate records are essential to understand low frequency variability in the climate system, including the drivers of decadal-scale hydroclimate extremes. It's over a decade since the Past Global Changes (PAGES) sub-project 'Australasia 2000' (Aus2k) aimed to compile and objectively review a database of palaeoclimate records for the last 2000 years in Australasia. The majority of records in this database are annually resolved, yet few of those records extend beyond 500 years in length. Sediment records from lakes and speleothems offer the potential to investigate hydroclimate variability further back in time, and in more populated regions, yet only nine records from Australia were found to meet the PAGES criteria for inclusion in the database [Dixon et al. 2017. 'Low Resolution Climate Records of the Last 2000 years', *Climate of the Past* 13, 1404-1433]. Selection criteria for Aus2k included temporal resolution, record length, dating precision and confidence in the proxy-climate relationship. The small number of Australian records which meet these criteria greatly undermines efforts to mitigate future climate risk.

This presentation with review the current status of 2000-year hydroclimate records in Australia. I will seek to explore (a) correlations and common modes of variability between Australian hydroclimate records; (b) correlations between low-resolution Australian hydroclimate records and annually resolved records from within and outside Australia; (c) geographical, methodological and archive-specific biases in the existing database, and potential to address those issues; and (d) consideration of opportunities and priorities for future research. As much as anything, this presentation will be a call for continued collaborative efforts to develop palaeoclimate data, databases and data-model integration.

# Hydroclimate variability of South Australia over the last 2000 years inferred from high-resolution oxygen isotope records

Mahfuzur Rahman[1*], Lucinda Cameron Duxbury[1], Haidee Cadd[2], Robert Matthew Klaebe[1], John Tibby[1], Jonathan Tyler[1]

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Finer resolution of past hydroclimate data is crucial for understanding the recurrence frequency of extreme events (droughts and deluges) and robust decision-making for environmental and economic sustainability. This study presents a ~sub-decadal-scale hydroclimate reconstruction based on lake sediment ostracod shell stable isotopes from Lashmars Lagoon, Kangaroo Island, covering the past ~2000 years. The $\delta^{18}O$ records demonstrated a series of higher $\delta^{18}O$ values associated with dry periods and lower $\delta^{18}O$ values were correlated with wet periods. Wet periods were found to dominate during the first millennium of the common era including the medieval climatic anomaly time range. Despite that, there are higher chances of occurrence of at least a few droughts in the study area within the dry periods. Reconstructed major climatic drivers for the last 2000 years demonstrated that ENSO, SAM, and IOD were simultaneously active, and their combined influences drove the hydroclimate of the study area. Comparison with reconstructed indices for major ocean–atmosphere interactions proves that the wetter condition in the study area occurred due to the influences of negative SAM, La Nina, and negative IOD phenomena and dry episodes for El Nino, positive SAM, and positive IOD activity.

# Tufa records of Holocene hydroclimate and freshwater availability at Murujuga rock art province

Mather, Caroline[1]; Tucker, Maurice[2]; Leopold, Matthias[3]; Levchenko, Vladimir[4]; O'Leary, Mick[5]; McDonald, Jo[1].

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Murujuga (the Dampier Archipelago) in northwest Western Australia is one of the world's largest rock art provinces, with over 1 million engravings. The art and other archaeological evidence in this cultural landscape are an important record of human responses to the changing climate following the last ice-age. 130 m of sea level rise following Last Glacial Maximum (LGM ~22 kya) transformed Murujuga from an inland range to a coastal archipelago. Here we present our study investigating freshwater carbonate (tufa) as geo-archives to inform on the environmental and climatic changes that impacted this region during the Holocene. The tufa are distributed in stepped creek systems that cross-cut the meta-igneous bedrock of Murujuga. Tufa cascade deposits are common in gorges and areas of elevation change where water flow can be turbulent. The creeks are surface water-dependent, but some are supplemented by perched seepage following recharge events. The formation of tufa is dependent on moderate to large rainfall events that recharge the landscape and can generate significant surface water flows and allow for precipitation of calcium carbonate. Petrographic analysis shows that the tufa are dominated by microbial fabrics, demonstrating that both hydrological and microbial processes are important for tufa formation. We have used radiocarbon dating of paired inorganic carbonate and organic matter residue samples from the tufa to provide accurate age records. Calibrated $^{14}C$ ages range from 0.5 to 9.7 cal. ka BP and constrain tufa formation to the Holocene. The initiation of tufa formation in the early- to mid-Holocene coincides with changing hydroclimatic conditions, following sea level rise and formation of the archipelago since the LGM. Further work is underway to refine tufa ages and integrate proxy data to build palaeohydrological records and enhance our understanding of the presence and persistence of water holes that would have been important for human occupation.

# Changing hydroclimate on the Darling Downs, Queensland: new evidence from dated Holocene tufa

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The Kings Creek catchment of the Darling Downs, southeast Queensland, is at the headwaters of the Murray-Darling system. Latest Pleistocene sediments that crop out in Ned's Gully, a minor ephemeral tributary, contain some of the youngest known uncontroversial Australian extinct megafauna fossils. The red stained Pleistocene fluvial deposits commonly contain calcrete and are overlain by brown fluvial sediments that lack calcrete and contain post-European farm animal remains beneath a thin veneer of modern soil. Large pieces of tufa erode out of the poorly indurated brown sediments and consist of carbonate deposits on a variety of aquatic plants, rocks and insect nests. Although no tufa forms in the area today, tufa morphologies are consistent with both flowing and standing water bodies, and trace element analyses are consistent with those interpretations. However, tufa has so far not been found in situ, only as clasts in the upper fluvial sediments. The small size of the catchment (~13 $km^2$), low topographic relief near the continental divide and shallow depth to basement limit the influence of groundwater flow in the tributary and suggest that tufa formation required significantly higher precipitation and infiltration than occurs in the region today. Radiocarbon dates for the tufas range mostly between 13 and 8 kyBP, with one sample at 4.5 kyBP. This is consistent with a significantly more humid environment in the earliest Holocene with a much drier climate becoming established at least since the mid-Holocene. These data add to a growing set of palaeoclimate data linking coastal Queensland and the more distal Murray Darling system with increased aridity since the early Holocene.

# Southern Hemisphere Common Era climate - are there enough palaeo-proxies?

Darren Ray

University of Adelaide

Reconstructions of global, southern hemisphere, and Australian climate, prior to instrumental records rely on highly spatially variable palaeo-proxy records - with southern hemisphere records significantly under-represented in proxy databases. Also, in general, numbers of available proxies is low early in the Common Era, rising significantly from around 1500CE.

Paleo-reanalysis reconstructions – the combination of palaeo-proxy record information with climate model representations – such as the Paleo Hydrodynamics Data Assimilation (PHYDA) and the Last Millennium Reanalysis (LMR) reconstructions, have been run and validated in prior work against instrumental records incorporating all available proxies through time. This may artificially inflate palaeo-reconstruction skill, particularly in the southern hemisphere.

Results are presented from Common Era temperature and rainfall reconstructions using:

1. a PAGES2K based proxy datasets (LMRdbv1)
2. An expanded Updated annually resolved proxy dataset combining PAGES2K, ISO2K and PalaeoWISE with significantly improved representation of southern hemisphere palaeo-proxies.

These results are from a novel timestep palaeo re-analysis approach adapted from the LMRt palaeo-reanalysis framework which allows evaluation of reconstruction robustness back in time.

Results indicate the added value of the extra southern hemisphere palaeo proxies in the Updated proxy database in improving representation of southern hemisphere temperature and rainfall. Also, while robust reconstructions at multi-decadal timeframes can be achieved at global and hemispheric scales, robust reconstructions of local/regional climate in much of the southern hemisphere may still be limited to the last few hundred years by low numbers of available Southern hemisphere proxy records.

# Hydrological Regime of Australian Lakes Over the Late-Quaternary and Holocene

Liam Thomas Clerke ; Paul P. Hesse

School of Natural Sciences, Macquarie University, Sydney, AUS

Continental-scale records of change in the hydroclimate of Australia were reconstructed by comparing 44 records of lake level change. Since earlier time-step reconstructions of Australian lake-level records, there has been a significant increase in the overall spatial and temporal coverage of data across Australia, in addition to the development of new analytical techniques capable of producing higher-resolution records. This study presents an updated lake level reconstruction for Australia on a regional- and continental-scale, through the application of uncertainty-based modelling techniques. The results suggest that lake-status was variable between sites across Australia over the last 30,000 years, with 'amplifier' lakes across arid and semi-arid Australia exhibiting opposing lake-status trends to 'rain gauge' lakes across humid Australia. Consistency in these results across experiments utilising different site inclusion parameters suggest a robustness against chronological and lake-status uncertainties. Good agreement between the dominant trend of amplifier lake level records and Murray-Darling Basin palaeochannel size trends suggests that runoff efficiency and amount dominate both proxies. They support greatly enhanced catchment runoff during periods of colder temperature. Conversely, high levels of rain-gauge lakes during the Holocene, when temperatures and evaporation were high, were the result of higher precipitation, at least in eastern Australia. While lake basin geometry has a large effect on individual lake level history, this reconstruction reveals the contribution of climate forcing to the hydrology of Australia's lakes and rivers.

# Growth and geochemistry ($\delta^{18}O$ and $\delta^{13}C$) of freshwater mussels as high-resolution hydrological proxies of Ngintait and Latji Latji Country, Central Murray River Basin

Stringer, Chloe[1]; Prendergast, Amy[1]; Garvey, Jillian[2,3]; May, Jan-Hendrik[1]; Drysdale, Russell[1]; First People of the Millewa Mallee Aboriginal Corporation[4]

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Sub-annual proxy archives are lacking from the Central Murray River Basin (CMRB) in south-east Australia, which lies on Ngintait, Latji Latji, and First People of the Millewa Mallee Country. Fortunately, freshwater mollusc shells are found extant and in archaeological contexts across the landscape, providing a unique opportunity to investigate human-mollusc-Country relationships and the paleoclimate. Sclerochronology applied to freshwater molluscs has proven itself to be an effective technique in answering vital questions about conservation, paleoenvironment, and archaeology. However, prior to the analysis of sub-fossil and archaeological samples, a species-specific calibration study must be conducted on modern specimens.

This paper presents the results of a multi-year modern calibration study for freshwater bivalve species *Alathyria jacksoni* in the Central Murray River Basin. The aim of the study is to understand how the growth and geochemistry (stable isotope ratios ($\delta^{18}O$ and $\delta^{13}C$)) of modern *A. jacksoni* shells relates to the surrounding environment and hydrochemistry of the current Murray-Darling Basin system. This is to evaluate if this species can serve as a reliable and robust paleoclimate archive when applied to archaeological and sub-fossil material. Specimens were collected live in 2017 and 2021-2023 alongside water samples, and water and climate data. Shell micromorphology was explored using SEM and Raman, while IRMS was used to analyse stable isotope ratios ($\delta^{18}O$ and $\delta^{13}C$) of calcium carbonate sampled in high-resolution from the mollusc's shell. We found a moderate correlation between carbonate $\delta^{18}O$ and local temperature, suggesting that environmental parameters, rather than biological effects, at least partially control shell geochemistry. This suggests that this species can serve as reliable palaeohydrological archives.

These results form the baseline of future studies investigating human-mollusc-Country relationships in this region, where people have been living for at least 15,000 years. Given the species' range, the results have implications for the wider Murray-Darling Basin.

# Palaeoenvironmental context for Palaeolithic hominins in the Levant from multi-proxy analyses of gastropod shells

Prendergast, Amy

[1]School of Geography, Earth and Atmospheric Sciences, University of Melbourne

In this talk I will give an overview of the latest results from my DECRA, which investigates whether seasonal environmental changes associated with rapid climate events played a role in the expansion of our own species, *Homo sapiens* (modern humans), and the demise of Neanderthals during MIS 3 in the Levant. We present high-resolution environmental reconstructions from stable isotope analyses of marine gastropods (*Phorcus turbinatus, Patella caerulea*), and land snails (*Helix spp.*) from several key Middle to Upper Palaeolithic archaeological assemblages in the Levant. Serially sampled $\delta^{18}O$, Mg/Ca, and Sr/Ca analyses of marine gastropod shells provide sub-monthly snapshots of sea surface temperature, whilst $\delta^{18}O$ and $\delta^{13}C$ analyses of terrestrial gastropod shells provide sub-seasonally-resolved records of rainfall variability and vegetation change. This evidence for fluctuating temperature, rainfall and seasonality regimes throughout MIS 3 appears to be linked with northern hemisphere millennial-scale climate oscillations These highly resolved environmental records, coupled with well-dated archaeological sequences provide a framework for assessing the complex interplay between early modern humans, Neanderthals and their local environments. The archaeological records show *Homo sapiens* occupation occurred during both warmer and cooler phases and during both high and low seasonality regimes, indicating that modern human populations showed resilience in the face of environmental fluctuations and resource uncertainty. We are examining whether this changing seasonality played a role in the demise of Neanderthal populations in the region. These paired cultural-environmental records demonstrate the importance of generating local, high-resolution palaeoenvironmental records to enable nuanced examinations of human-environment interactions during critical periods of the late Pleistocene.

# Hydroclimate variability in the eastern Kimberley, Australia, since the last deglaciation

Teresa Dixon[a], Rachel Rudd[b], Justine Kemp[c], Samuel Marx[d], Patrick Moss[a], Quan Hua[e], Hamish McGowan[a]

[a]School of the Environment, the University of Queensland,
[b]isoTROPIC Research Group, Max Planck Institute of Geoanthropology,
[c]Coastal and Marine Research Centre, Griffith University,
[d]School of Earth, Atmospheric and Life Sciences, The University of Woollongong,
[e]Australian Nuclear Science and Technology Organisation

The climate of the Kimberley region in northwest Australia is dominated by the Indo-Australian summer monsoon (IASM). This, as part of the wider Asian-Australian summer monsoon system, forms a major heat source integral to global atmosphere circulation and energy balance. Understanding of the palaeoclimate since the Last Glacial Maximum in the Kimberley, which is well placed to record IASM variations, is currently based on few records. Many of these have the potential to be confounded by local environmental factors such as topography, anthropogenic activity or marine processes.

We present a geochemical record spanning the last 17 ka in conjunction with a pollen and charcoal record from 5.7 ka to the present from the northeast corner of the Kimberley. The record comes from the floodplain of the Bullo River and as such represents variations in the 2000 $km^2$ Bullo River catchment hydroclimate. Our results show that the deglacial was characterised by a variable monsoon until the onset of the early Holocene wet interval at 12.8 ka. A prolonged dry period began at 5 ka and continued until the climate ameliorated at 1 ka. These results are broadly consistent with previous research and extend our understanding of deglacial and Holocene hydroclimate variability to the eastern Kimberley, 350 km east of previously published Kimberley palaeoenvironmental records.

# Age and paleoenvironments of the Simpson Desert lakes: Preliminary findings from a playa lunette

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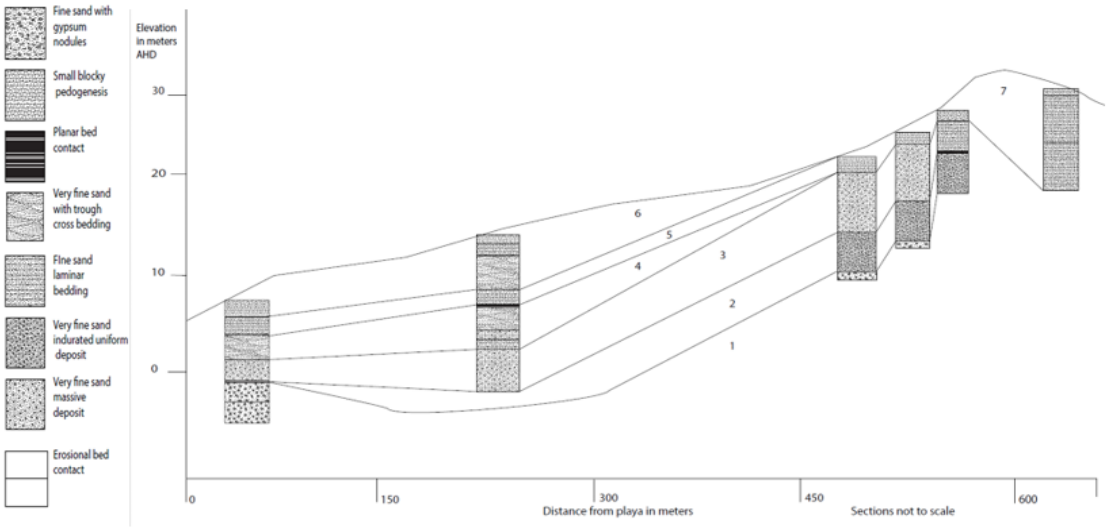
Affiliation/s

[1] Flinders University; [2] Adelaide University

The dryland playa lakes of the Simpson Desert are situated in one of the most arid areas of Australia. The playa lakes are closed basins with no surface outlet, no modern fluvial inlet and are fed by groundwater and local runoff. Many of the playas are bordered to the north by complex downwind, source bordering (lunette) dunes. While considerable research has been done to establish the formation and paleoenvironments of the large playa lakes of the Lake Eyre basin, notably Lakes Eyre and Frome, and to a lesser degree, Lake Callabonna, research in the region is in its infancy and no similar studies have been conducted in the Simpson Desert. Consequently, the age and hydrological history of the playa lakes is unknown. This research aims to systematically reconstruct the geochronology and paleoenvironment of the region through survey and analysis of the lunette dunes of the Simpson Desert playa lakes.

Here we present findings from the survey and analysis of a lunette in the eastern margin of the Simpson Desert playa region. The RRL2 field site consists of an amorphous shaped playa with two consecutive lunettes on the northern edge, conforming to the current shoreline. Results show three lunette building episodes since playa formation, with at least one episode of evaporite mineral deflation. Detailed chronology using luminescence dating methods provide the first dates of playa lake formation in the Simpson Desert lakes region. Sedimentary analysis provides additional information on the paleoclimate and paleoenvironment of Australia's arid zone during the late Pleistocene. This research will contribute a valuable chronological, environmental and hydrological framework for the Simpson Desert playa lakes region during the late Pleistocene, adding to Quaternary arid zone climate studies in southeastern Australia.


Fine sand with gypsum nodules
Small blocky pedogenesis
Planar bed contact
Very fine sand with trough cross bedding
Flne sand laminar bedding
Very fine sand indurated uniform deposit
Very fine sand massive deposit
Erosional bed contact
Elevation in meters AHD
30
20
10
0
1
2
3
4
5
6
7
0
150
300
450
600
Distance from playa in meters
Sections not to scale

# Hydroclimate of Australia's southern arid margin during human arrival: insight from subaqueous speleothems

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Our understanding of the climatic conditions faced by humans upon arrival in Australia is both temporally and spatially fragmented. A cave in the Ikara-Flinders Ranges contains speleothems that shed light on the palaeohydrology of Australia's southern arid margin through the Last Glacial Period. The timing of speleothem growth phases suggests there were three multi-millennial periods where the region experienced a more positive water balance, each of which aligns with Southern Hemisphere summer insolation maxima. This implies that moisture delivery was governed by the strength and/or latitudinal position of the Indo-Australian Summer Monsoon, meaning the continental interior to the north of the cave site would also be receiving monsoonal rainfall. These findings support the proposed 'superhighway' through central Australia (Crabtree et al. 2020; Bradshaw et al. 2023). A period of especially high moisture availability coincides with the earliest evidence of human presence at the Warratyi shelter, 250 km north of the cave site (Hamm et al. 2016).

# Palaeoclimate in Australia's arid interior: Insights from clumped isotope analysis

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Quantitative records of past temperature variability in arid environments are crucial for validating climate models and their ability to capture the full range of the Earth's climatic regions. However, arid zone temperature reconstructions are rare, particularly in the Southern Hemisphere, including Australia. The clumped isotope thermometer provides a novel approach to potentially address this demand by allowing the estimation of carbonate precipitation temperature independent of environmental water isotopic composition. Two types of carbonate materials were selected for clumped isotope temperature reconstructions in arid central Australia: fossil mollusc shells deposited within the ancient shoreline sediments of currently dry Lakes Eyre, Frome, and Callabonna; and tufa deposits formed at mound springs fed by continuous discharge of Great Artesian Basin groundwater.

Air temperatures inferred from clumped isotope measurements have been used to reconstruct mean annual air temperatures (MAAT) back to ~370 ka, with most data from the last 100 ka. Reconstructed MAAT were up to 10°C cooler than present between ~50-28 ka, which supports estimates for the Last Glacial Maximum in central Australia, as generated by hindcast palaeoclimate models. Variability in the $\delta^{18}O$ of lake molluscan carbonate appears to have been largely driven by changes in environmental water $\delta^{18}O$, reflecting differences in the lake's hydrological balance at the time of shell formation. For the tufas, however, this was not the case, reflecting the different hydrological controls on the two water sources. Overall, the results of this study indicate that air temperatures in arid central Australia varied markedly in response to global forcing (pCO2, orbitally forced insolation), providing context for the drying up of mega-lakes, the arrival of people and the extinction of the Australian megafauna.

# Arid zone dendrochronology of the widespread and ecologically critical Mulga tree

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Mulga (*Acacia aneura*) cover a landmass greater than 1.5 million km$^2$ across the arid zone of Australia. They take many forms from low standing shrubs to bushy crowned trees standing up to 10m tall with their shape dependent on the resources available to help them grow. Like many *Acacia* species Mulga bark and leaves have medicinal uses and are a food source for native and feral animals. Mulga are fire-sensitive and also show reduced growth during periods of intense drought: both these factors are cause for concern due to potential loss of this species in parts of the Australian outback.

A loss of Mulga in the natural environment would be devastating as this species is critically important both as part of the Australian ecosystem but also because of their carbon-fixing ability which is important for active and upcoming government environmental schemes. It is believed that Mulga can live for up to 300 years and therefore represent long-term carbon sinks, but this age is calculated based off models of height and diameter rather than direct measurements. Up until recently such estimation was a necessity as understanding growth relationships in this species directly was not possible. However, our recent work applying a multi-technique dendrochronological approach developed using trees from the Australian tropics has shown that actual ages and growth-climate relationships can be developed from arid zone Mulga trees.

Here we present results from a preliminary study demonstrating how combining visual ring analysis, radiocarbon dating, and ring-width measurement has allowed for the identification of annual ring boundaries and age determination in seven Mulga samples. Possible growth relationships to climate and environmental drivers will also be explored and directions of future study outlined.

# Palaeoenvironmental context for the restoration of traditional land management in McLaren Vale, South Australia

Griffiths, Nashley[1]; Tyler, Jonathan[1]; Edwards, Kym[1]; Francke, Alexander[1]; Duxbury, Lucinda[1]; Malone, Gavin[2,3]; Telfer, Karl[3]; Jacobsen, Geraldine[4]; Gadd, Patricia[4]; Tibby, John[5]; McInerney, Francesca[1,6,7]; Loehr, Stefan[1]; Moffat, Ian[8,9]

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Wetlands are significant environments for floral and faunal biodiversity, and key to counteracting human impact. Unfortunately, wetlands are also sensitive to climatic and anthropogenic change and are at risk of being lost. Conservation and rejuvenation are critical to the survival of wetland environments within agricultural areas. This study aimed to reconstruct the palaeoenvironmental history of a wetland at Lot 50 – Kanyanyapilla (a.k.a Lot50K), a bi-cultural restoration project in the viticultural region of McLaren Vale, South Australia. A 4 m core from Lot50K was found to be devoid of many traditional proxies for environmental change, such as pollen and diatom remains. Root fragments, radiocarbon dated to be 'modern' were found to depths of 3 m. However, bulk sediment radiocarbon dates suggest that the wetland formed at approximately 16 ka, and ITRAX X-ray fluorescence scanning, coupled with X-ray diffraction analysis, indicated three distinct units of past sedimentation. We used changes in the sediment elemental, mineralogical and organic composition to infer changes in depositional environment through the Holocene. Results from the study are used to suggest potential restoration and conservation options for wetlands in McLaren Vale.

# Holocene vegetation and European settlement controls erosion on Kangaroo Island (Karti/Karta), South Australia

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Kangaroo Island (Karti/Karta), located off the coast of South Australia, is thought to not have been occupied by aboriginal groups for the last several millennia; whilst archaeological evidence does indicate their presence at least until the Early to Mid Holocene. The island therefore acts as an excellent natural laboratory to study the landscape's response to the abandonment of cultural management practices, and the subsequent impact of European arrival.

Here, we unravel erosional processes in the catchment of Lashmar's Lagoon, located at the eastern shoreline of the island, during the last ~7,000 years. Novel trace metal isotope and pollen data indicate that prior to European arrival, erosion is strongly tied to catchment vegetation change, which is likely controlled by a complex interplay of cultural management practices and climate. The strong tie between erosion and vegetation is supported by multivariate statistical analyses but disappears after the arrival of European settlers. Since then, significant land clearance seems to have significantly amplified erosion processes in the catchment.

# Twentieth Century change in the fire regimes of the Blue Mountains of NSW as recorded in the accumulation and character of charcoal in Temperate Highland Peat Swamps

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Affiliation/s

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A significant concern surrounding the 2019-2020 Australian 'Black Summer' bushfires, as well as other similar recent events globally, is the question as to whether these represent a new and more extreme fire regime with an increase in frequency, intensity or area burnt. While Australia's terrestrial ecosystems have been actively shaped by fire for millennia, increasing severe fire weather or climatic variability due to anthropogenic climate change may be resulting in more extreme fire. This study utilizes high-resolution 14C dating, charcoal accumulation (CHAR) and Raman spectroscopy to examine fire over the past century across the upper Blue Mountains of NSW in eastern Australia. We particularly focus on changes to fire intensity and severity using parameters derived from the position and shape of features in the sub-bands of Raman spectra which have previously been shown to be sensitive to the structure of charcoal and 'thermal maturity'. These, together with CHAR, are used to show that trends across the Twentieth Century in the Blue Mountains landscape are not consistent with the hypothesis that fire is becoming more severe. Ultimately our goal is to use this calibration exercise to quantify links between charcoal and fire, such that this can be used to better characterize fire regimes over the many thousands of years (represented by the sediments in the mires of the Blue Mountains).

# An environmental reconstruction of Te Whakaraupō | Lyttelton Harbour

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Affiliation/s

[1] School of Earth and Environment, University of Canterbury, Christchurch, New Zealand; [2] Department of Geology, University of Otago, Dunedin, New Zealand; [3] Australian Nuclear Science and Technology Organisation, NSW, Australia

Understanding how landscapes and environments change through time pre- and post-human settlement is key for future management response. Banks Peninsula, an eroded shield volcanic complex with infilled valleys, is a heavily modified landscape with cultural, historical and geological significance. Te Whakaraupō | Lyttelton Harbour located in Banks Peninsula is a dynamic landscape that contains the most extensive saltmarsh and mud flat complexes within the Peninsula, which are host to threatened and at risk flora and fauna. It is therefore key to identify past environmental conditions and how these have varied through time with changes in land use. To do this, we collected a transect of three cores ranging between marine and terrestrial conditions which date back to 4,900 cal yr BP. Using a multiproxy approach consisting of sedimentology, micro-fossils, geochemical and geochronological analyses we have reconstructed past vegetation changes, identified changes in land use post-European settlement as well as produced a history of sediment infilling and provenance within Te Whakaraupō over the middle-late Holocene. This research provides the first vegetation reconstruction for the northern part of Banks Peninsula and also provides greater insight into sedimentation rates and provenance of the harbour. This research will provide information for future environmental management response to increased environmental variability and land use.

# Pollution history and anthropogenic-induced increase in the transport of toxic metals from Australia to the Southern Ocean islands

Schneider, Margot[1]; Schneider, Larissa[1]; Saunders, Krystyna[2]; Latimer, James[1]; Haberle, Simon[1];

Affiliation/s

[1] Australian National University; [2] Australian Nuclear Scientific Technology Organisation

Mercury (Hg), is a volatile metal of international concern due to its toxicity, with a large atmospheric emission and transport capacity. The biogeochemical cycle of Hg is sensitive to changes in climate, yet our understanding of the specific impact of climatic factors on the Hg cycle remains limited. A primary challenge in modern Hg research, particularly in the context of climate change, involves distinguishing alterations in Hg levels resulting from human activities from those driven by climatic variations. This research focuses on examining how industrialisation and climate change have increased toxic metal pollution in the Australia-Pacific region. Studies have found Hg in remote areas of Australia, the Southern Ocean, and Antarctica, with increased deposition occurring post-industrial revolution and particularly in the Anthropocene. We will use a multi-proxy framework, supported by AMS 14C and 210Pb dating to interpret climatic events in Southern Australia, and sub-Antarctic islands (Macquarie and Campbell) for the past 8,000 years. By combining Hg analysis, (and arsenic, lead, and cadmium), temperature records, carbon-to-nitrogen ratios, diatom analysis, XRF, and Hg isotope analyses, we aim to reconstruct and disentangle the impacts of anthropogenic emissions from those caused by climate change, such as the intensification of the southern hemisphere wind belt on the deposition of toxic metal pollution To understand the biogeochemical processes and dynamics governing mercury behaviour in lacustrine ecosystems, it is necessary to integrate multiproxy paleolimnological methodologies. This comprehensive approach facilitates the precise quantification and interpretation of mercury deposition sources and accumulation rates in the context of varying climatic regimes. This research will inform contamination amelioration strategies, and provide crucial information for Australia to meet its international obligations under the Minamata Convention on Mercury. This research is in collaboration with the Australian Nuclear Science and Technology Organisation, the British Antarctic Survey, and the University of Tianjin, China.

# The Argentine pampas during the late Quaternary: sensitivity to climate change

Joaquin Spinelli[1], Paul Hesse[1], Kira Westaway[1]

Affiliation/s

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The Argentine pampas are a productive sector in southern South America where a large part of the grains consumed worldwide are produced. In the Utracan-Argentino Valley, this production occurs on sand dunes fixed by vegetation, affected by fluctuating periods of drought. Its recent history has shown that the combination of poor soil management and drought can cause the remobilization of these dunes and the loss of the superficial - and most fertile - layer of the soil profile. This work combines the quantification of the variations in the rain and wind in the area for the last seventy years, and the study of the processes forming the valley's aeolian landforms. The dunes were active in at least two periods during the late Quaternary: 5-4 ka and 2-0.8 ka because of changes in regional atmospheric circulation, lower precipitation, and reduced vegetation cover. These results strengthen the knowledge of the geomorphological evolution of this productive region, the sensitivity of the dunes and the factors that cause it.

# The speleothem proxy - the view from groundwater recharge monitoring

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Affiliation/s

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Australia's National Groundwater Recharge Observing System (NGROS) is monitoring water movement from the surface to the groundwater by deploying drip water counters in underground spaces such as caves, tunnels and mines (Baker et al 2023). The results from the first two years of monitoring in southern and eastern Australia has identified the rainfall recharge thresholds needed for this 'deep drainage' or 'potential recharge' water to reach our monitoring sites at locations that include Budj Bim (VIC), Naracoorte (SA), Wellington (NSW) and Capricorn Caves (QLD). In these water-limited environments, the thresholds are typically greater than ~10 mm of rain over 48 hours in winter months and cooler climates and can reach over ~20 mm of rain in summer months and warmer climates. These thresholds lead to a relatively small number of rainfall events each year that have sufficient magnitude to generate groundwater recharge in southern and eastern Australia, and it is water from these events that is directly or indirectly involved in many speleothem paleoenvironmental proxies. Here we provide a groundwater recharge perspective on speleothem oxygen isotope proxy, informing its use as a paleorecharge proxy in water limited environments as demonstrated recently (Tadros et al 2022; Priestley et al 2023). NGROS data is available from https://groundwater.unsw.edu.au/

Baker, A., et al. 2023 An underground drip water monitoring network to characterize rainfall recharge of groundwater at different geologies, environments, and climates across Australia, *EGUsphere* [preprint], https://doi.org/10.5194/egusphere-2023-2053, 2023.

Priestley, S.C., et al. 2023. Caves demonstrate decrease in rainfall recharge of southwest Australian groundwater is unprecedented for the last 800 years. *Commun Earth Environ* **4**, 206.

# The speleothem fire record: outcomes from a Discovery Project

Treble, Pauline[1,2]; Baker, Andy[2]; Campbell, Micheline[2]; McDonough, Liza[1,2]

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A serendipitous discovery from long-running cave monitoring revealed that dripwater chemistry and hydrology changed after wildfires[1], and this was subsequently confirmed by controlled experiments[2]. This led to an ARC Discovery Project (DP200100203) to establish whether fire events could be reconstructed from cave speleothems. This presentation will summarise the DP outputs and outcomes for the AQUA community.

The study area is south-west Western Australia. The project has verified that speleothem trace element data recorded modern fires known to have impacted shallow caves in Yanchep National Park, and yielded a speleothem dataset of fire frequency for 1760-2005 CE, showing a clear change in fire activity after colonisation in the late 1800s[3]. Deeper caves in the Margaret River region recorded only the most severe fires in the historical record[4], supporting the hypothesis that shallow caves are more suitable for speleothem-based fire records. We analysed the inorganic and organic chemistry of ash leachates, and found that the inorganic chemistry of ash varied with both site and burn severity, supporting the hypothesis that speleothems may record burn severity as well as fire frequency[5]. In the final phase of this project, we investigated synchrotron infrared microspectroscopy as a high-resolution but relatively unexplored method to detect changes in speleothem organic matter before and after fire events[6]; burn severity is being further assessed in speleothem trace element data; and a record of early Holocene fire activity is underway[7].

**References**

[1]Nagra et al. A post-wildfire response in cave dripwater chemistry. Hydrol Earth Syst Sc (2016);

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[5]Campbell et al. Combustion completeness and sample location determine wildfire ash leachate chemistry. doi.org/10.22541/au.170689252.26414470/v1 (2024 pre-print);

[6]McDonough et al. Fire-induced shifts in stalagmite organic matter mapped using synchrotron infrared microspectroscopy (in prep.);

[7]Campbell et al. Calibrating a speleothem fire severity signal using coeval stalagmites from southwest Australia. (See abstract AQUA 2024).

# Oxygen isotope ratios in plant phytoliths as a proxy for past climates and environments

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Fossil silicate phytoliths – residual cellular structures from plants – are abundant in Australian sedimentary and archaeological deposits, presenting an opportunity to use the oxygen $^{18}O/^{16}O$ isotope ratios ($\delta^{18}O$) as a proxy for past climates and environments.

Previous studies have shown that precipitation oxygen isotope ratios, relative humidity, and temperature have major control on the oxygen isotope composition of phytoliths. It is hypothesised that relative humidity will have the strongest control on the oxygen isotope values of phytoliths sampled both in naturally growing plants and accumulated in topsoil since previous studies demonstrate its strong influence on leaf water isotopic composition, the source of biogenic silica bound oxygen.

Phytoliths were extracted from modern plant and topsoil samples which were collected across a large climate gradient across continental Australia. It was hypothesised that phytoliths from plants of different species growing at the same location should have similar $\delta^{18}O$ values and would show correlation with recent climate records. $\delta^{18}O$ values of phytoliths from soils were expected to be similar to the plants at the same location, albeit with a better correlation to longer term climate, since phytoliths accumulate in soils over time.

Measured $\delta^{18}O$ values of phytoliths sampled from both modern plants and topsoil were correlated with local climate data and modelled $\delta^{18}O$ values in leaf water and phytoliths. Results indicate that both temperature and leaf water isotopic composition (controlled by relative humidity) influence the oxygen isotope values. Interestingly, there is a weaker correlation between climate and the $\delta^{18}O$ values of phytoliths sampled directly from plants compared to $\delta^{18}O$ values of soil phytoliths. The oxygen isotope ratios of phytoliths from topsoil are not well correlated with annual average relative humidity but correlate well with relative humidity over the warmest months of the year (December-February). This is the first time that measured oxygen isotopes of plants and soils from the same sites have been compared to each other, providing a better understanding on how climate variability is recorded in plants and sediments.

# East Asian Monsoon response to abrupt climate change during the last ice age: evidence from the sediments of Lake Suigetsu, Japan

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The East Asian Monsoon (EAM) impacts almost half of the world's population, however its trajectory for the future remains largely unknown in light of current rapid climate change.

This project focuses on the precisely dated varved sediments of Lake Suigetsu, Japan, and episodes of abrupt global change (at similar time scales to what is experienced today) leading into the Last Glacial Maximum. Building on previous research, this study focuses on the oxygen isotope composition of siderite, as well as total organic carbon, biogenic silica and siderite concentrations, to reconstruct climate and hydrological change from ~55,000 to 20,000 years before present.

In particular, we will describe the potential of the relatively rare application of siderite oxygen isotopes as a proxy for hydrologic change in the absence of calcites. These data represent one of the most precisely dated oxygen isotope records from Japan during Marine Isotope Stage 3, exhibiting distinct sub-millennial scale events which vary with respect to synchronicity with other prominent records in the region. We therefore interpret these data with respect to intra- and inter-hemispheric teleconnections, and the underlying mechanisms of EAM variability in the context of regional and global climate change. By improving knowledge of millennial scale variability of the EAM, our aim is to contribute to improved understanding of future climate in the region.

# High-resolution paleoenvironmental reconstructions of MIS 3 Central Europe from oxygen and carbon isotopes from mammal teeth

Liu, Zuorui[1]; Prendergast, Amy[1]; Nejman, Ladislav[2]; Škrdla, Petr[3]; Roblíčková, Martina [4]; Drysdale, Russell[1]

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In Europe, the period of approximately 50 to 35 ka BP during Marine Isotope Stage 3 (MIS 3) has been of key ongoing interest in archaeological studies, which is often referred to as the Middle to Upper (M-UP) Palaeolithic transition. During this time, there was a major expansion of anatomically modern humans (AMHs) across Eurasia, whilst Neanderthals (*Homo neanderthalensis*) became extinct. Some suggest that Neanderthal extinction may be related to the abrupt environmental changes that occurred during MIS 3. Understanding the extent to which climate change played a role in Neanderthal extinction requires reconstructions of local paleoenvironmental records at seasonal to sub-seasonal resolution. Stable isotope records from animal teeth provide one of the few paleoenvironmental proxies available at such resolution in the mid to high latitudes. Therefore, this study aims to reconstruct local, high-resolution paleoclimates in MIS 3 Central Europe using teeth of Pleistocene mammals. Sveduv Stul and Pod Hradem are two caves located in the Moravian Karst, Czech Republic, and both have potentially been occupied by AMHs and/or Neanderthals during MIS 3. These caves also preserve an extensive Pleistocene mammal remains, some potentially present as a result of human hunting practices. Teeth of horses (*Equus ferus*) and cave bears (*Ursus spelaeus*) found in these two sites were studied for oxygen ($\delta^{18}O$) and carbon ($\delta^{13}C$) isotopes to reconstruct the paleoenvironments and paleovegetation respectively. Tooth enamel was sequentially drilled at millimetre resolution following the growth direction, and the obtained powder was then analysed using isotope ratio mass spectrometry. These highly resolved isotopic records provide paleoenvironmental information at sub-seasonal to sub-monthly resolution, which help to reconstruct local precipitation, air temperature, hydrology and vegetation cover. They also enable further assessment of the complex interplay between animals, humans and their local environments in MIS 3 Central Europe.

# Hydroclimate changes during Termination I from a Tasmanian stalagmite

Drysdale, Russell[1]; MacGregor, Claire[1]; Cooley, Sarah[1]; Hellstrom, John[1]; Jasper, Claire[2], Treble, Pauline[3]; Wong, Henri[3]; Eberhard, Rolan[4]; Kearns, Rebecca[4]; Larcher, Renee[4]; Demeny, Attila[5]; Sun, Yuchen[6]; Zhang, Xu[7]; Lohmann, Gerrit[6]

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In the middle latitudes of the Southern Hemisphere, the last deglaciation (Termination I) is well represented by records from lakes and alpine glaciers, most of which provide information on terrestrial temperature changes. However, much less is known about variations in hydroclimate across this interval. We present a high-resolution, multi-proxy time series across Termination I from a Tasmanian stalagmite. Coherent patterns in stable oxygen and carbon isotopes, growth rates, initial uranium isotope ratios and trace elements (Mg and Sr) indicate multiple, millennial-scale episodes of hydrological change over northern Tasmania during Termination I. A more positive water balance, inferred from low carbon isotope ratios and low Mg/Ca and Sr/Ca (prior calcite precipitation proxies), occur when the climate was likely cooler (low growth rates and low oxygen isotope ratios); periods showing converse excursions point to warmer but drier conditions.

The pattern of hydroclimate changes is similar to that of iceberg-rafted debris (IBRD) flux recorded near the Antarctic Peninsula. Periods of increased iceberg flux coincide with effective moisture increases over northern Tasmania. This suggests that iceberg meltwaters altered ocean and atmospheric circulation, bringing cooler, and possibly wetter, conditions to Tasmania. Climate model results show that iceberg discharge events increase sea-ice cover and produce negative surface-temperature anomalies over the Indian, Atlantic and SW Pacific sectors of the Southern Ocean. Although rainfall itself does not increase, water balance over Tasmania is substantially enhanced during these events, consistent with the speleothem data. There is some evidence that the re-advance (retreat) of some NZ glaciers may coincide with enhanced (reduced) moisture balance over Tasmania, implying that NZ glacier history through T-I may be more nuanced than the prevailing model suggests.

Our results suggest that ice discharge along the Antarctic margin can influence regional hydroclimate. This has implications for middle-latitude climate responses to future Antarctic ice-sheet melting.


# Thursday 27th June

# Abstracts for poster presentations

# Exploring a speleothem fire severity signal using coeval stalagmites from southwest Australia

Campbell, Micheline[1]; Treble, Pauline[2,1]; Baker, Andy[1]; McDonough, Liza[2]; Howard, Daryl[2]; Sinclair, Dan[3]

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Cave stalagmites have recently been shown to record past fire events[1], primarily via the presence of certain trace elements leached from ash deposited above the cave. This approach yields the potential for these metals to also record burn severity as well as fire frequency[2]. Analysis of ash leachates has demonstrated that wildfire ash chemistry varies by both site and with burn severity, further supporting that stalagmite inorganic geochemistry may also record burn severity[3]. To explore this hypothesis, we undertook micro-coring of multiple modern stalagmites from shallow caves at Yanchep National Park, where stalagmites are known to contain annual growth layering. These caves were impacted by recent wildfires and satellite imagery was used to constrain burn timing, area and severity. High-resolution (sub-seasonal) trace element data was measured in the micro-cores using *in situ* laser ablation and Synchrotron µ-XRF techniques. Multi-proxy statistics are used to determine the timing of fire events in the proxy record[1]. We aim to determine if the geochemical 'finger print' of the fire changes with burn severity. We also draw on our dataset of ash leachate chemistry from this location to interpret these data. Results will be of interest to both the Australian and international palaeoenvironmental community. The ability to reconstruct past burn severity as well as frequency at very high (annual) temporal resolution has implications for how we manage landscapes under both present and future climate.

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2. Campbell, M. *et al.* A Review of Speleothems as Archives for Paleofire Proxies, With Australian Case Studies. *Reviews of Geophysics* **61**, e2022RG000790 (2023).

3. Campbell, M. *et al.* Combustion completeness and sample location determine wildfire ash leachate chemistry. Preprint at https://doi.org/10.22541/au.170689252.26414470/v1 (2024).

# Key considerations in developing precisely dated uranium-thorium chronologies from speleothem

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Speleothem palaeoclimate records are well known for their accurately and precisely dated uranium-thorium chronologies. This has positioned speleothems as a key archive for precisely constraining the timing of climate events such as Dansgaard-Oeschger events, the Younger Dryas and glacial terminations. Speleothem records and chronologies are frequently drawn on by Quaternary scientists to make comparisons to other archives, or to provide chronological tie points. Uranium-thorium age determinations can be made back to approximately 500,000 years, with relative uncertainties typically smaller than 0.5% (2-sigma), reaching 0.1% (2-sigma) in state-of-the-art studies of the late Pleistocene. There are, however, a number of important considerations that arise in the process of developing speleothem uranium-thorium chronologies, that can potentially affect both the precision and accuracy of the final chronology. These considerations are important to understand for those who produce precise speleothem chronologies, and those who draw on them. Here we present a number of simulations to explore the potential effect of various factors on the accuracy and precision of speleothem uranium-thorium based chronologies. These considerations relate to factors that include: selection of the dating sample location; correction of ages for initial thorium activity ($^{230}Th/^{232}Th$); outlier identification and resolution; consideration of sample depth range; and interpolation uncertainty in the age model. We identify a set of best practices for producing accurate and precise uranium-thorium based chronologies across a particular climate event, within the constraints of limited age determinations.

# ANSTO's Mighty Itrax – Serving Australia and beyond!

Patricia Gadd

Australian Nuclear Science and Technology Organisation (ANSTO), Lucas Heights, NSW, Australia.

The Itrax X-ray Fluorescence (XRF) core scanner, housed within ANSTO's Environmental Research and Technology Group, has been a powerful tool since its acquisition in 2012. Funded through an ARC LIEF grant in collaboration with AINSE and university partners, the Itrax has revolutionised the study of sediment and rock cores, speleothems, corals, and wood samples in Australia.

Since its operational debut, the Itrax has meticulously analysed more than 2 kilometres of cores which has aided in reconstructing historical climate and environmental conditions.

In this poster, we will showcase:

- Global Reach: A map illustrating the geographical distribution of Itrax-scanned cores from Australia and around the world.
- Sample Locations: A breakdown of where these cores were collected.
- University Collaborations: Highlighting the role of university partners.
- Scientific Impact: The number of publications in the quaternary space resulting from Itrax data.

# High-resolution Holocene hydroclimate reconstruction from Tongan stalagmites

Ghoochani Nejad, Hesam Zareh Parvar[1]; Borsato, Andrea [1]; Verdon-Kidd, Danielle[1]; Frisia, Silvia[1]; Sinclair, Dan[2]; Drysdale, Russell[3]; Cheng, Hai[4]

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Stable isotope ratios of stalagmite carbonate layer are widely utilised to reconstruct hydroclimate variability of the Holocene. This epoch, spanning approximately the last 11,700 years, represents a pivotal chapter in Earth's history, and includes dramatic climate shifts that offer crucial insights into the future trajectory of our planet's climate. There is currently a paucity of Holocene data from the Southern Hemisphere and, as such, there are conflicting theories about how the Southern regions may have responded during these events. However, the interpretation of $\delta^{13}C$ and $\delta^{18}O$ values in South Pacific speleothems can be challenging due to both regional and in-cave factors, and logistic aspects that prevent continuous cave monitoring. A multi-proxy approach on coeval stalagmites can, however, provide robust hydroclimate information.

We here present preliminary results from the study of three stalagmites retrieved at Ana Maui ('Eua) and Ana Hulu (Tongatapu) caves in Tonga, which likely record shifts of the South Pacific Convergence Zone (SPCZ), the largest component of tropical circulation on our planet, through time. The stalagmites cover almost the entire Holocene period, from ca. 500 to ca. 12,500 years BP, with growth rates between 50 and 300 µm/year, thus offering the potential to obtain an annually resolved record of rainfall variability. The stalagmite stable isotope ratios variability was complemented by petrographic observations that allowed obtaining accurate reconstructions of coeval changes in the infiltration regime.

The study is part of a larger ARC-funded project investigating the hydroclimate variability across the South Pacific during the Holocene.

# **F**iordland **A**ssessment of **C**limate, **E**nvironment and **T**ectonics (FACET): Report from the ICDP workshop

Moy, Chris[1]; Riesselman, Christina[1]; Gorman, Andrew[3]; Wilson, Gary[2]; Gilmer, Greer[3]; McLeod, Rebecca[1]; Rollins, Chris[3]; Stirling, Claudine[1]; Smeaton, Craig[4]; Clarke, Leon[5]; St-Onge, Guillaume[6]; Beagley, Jack[1]; Clark, Kate[3]; Saunders, Krystyna[7]; Lembke-Jene Lester[8]; Strachan, Lorna[9]; Gegg, Lukas[10]; Vandergoes, Marcus[3]; Whibley, Luke[1]; Illing, Matt[9]; Forwick, Mattias[11]; Brunet, Morgane[6]; Vats, Nishant[12]; Pyne, Alex[13]; Herbert, Lisa[14]

Affiliation/s

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Here we outline the outcomes of the ICDP scientific drilling workshop **F**iordland **A**ssessment of **C**limate, **E**nvironment and **T**ectonics (FACET) held in Aotearoa New Zealand in 2023. Participants from 12 countries gathered and discussed priorities for long coring in the NZ fiords and potential drilling sites to evaluate the timing of deglaciation, sea level incursion, fjord circulation, climate change, carbon burial rates, earthquake frequency and other relevant topics.

New Zealand's southern fjords lie at the juncture of the Antarctic Circumpolar Current, the Southern Hemisphere Westerly Winds, and the New Zealand plate boundary. Regional tectonics has resulted in a significant mountain range close to the sea that is now dissected by deep fjords partially filled by thick sedimentary sequences. As a result, New Zealand fjords provide an excellent opportunity to develop long, high-resolution sedimentary records of climate and biogeochemical cycling that can constrain key Earth system processes. They also provide an opportunity to study ongoing tectonic processes from a plate boundary known to produce significant earthquakes. Fjord sediment records provide critical context and perspective that can link the changes we observe today with the long-term background and range of variability recorded in the geologic record. Yet, our temporal perspective is relatively short because current sedimentary records only span the last few thousand years or are floating stratigraphies that represent a "snapshot" of late Pleistocene sedimentation.

# Organic Molecular biomarkers as proxies for past temperature from Australian lake sediments

Griffiths, Nashley[1]; Tyler, Jonathan[1]; Francke, Alexander[1]; Hall, Tony[2]; Shanahan, Timothy[3]; Cadd, Haidee[4].

Affiliation/s

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Understanding past temperature change, particularly temperature trajectory throughout the last 2000 years, is critical to managing future climatic variations and prediction of responses in ecology and the hydrological cycle. Attempts to reconstruct Australian palaeotemperature throughout the Holocene are often forced to draw upon proxies that are geographically distant from the location in question. Issues arise from this approach, such as reconstructed temperature that may not accurately represent the region. By increasing the number of reliable and replicable palaeotemperature records across the mainland of Australia, we can reduce the necessity for reliance on external records when reconstructing past temperature across the continent. Advancements in the use of bacterial biomarkers over the last two decades has provided us with a novel set of potentially useful proxies that can be used to reconstruct past environmental conditions. Through my PhD, I aim to use a particular group of bacterial biomarkers – branched glycerol dialkyl glycerol tetraethers (bGDGTs) – extracted from crater lake sediments in Victoria, to infer changes in regional palaeotemperature through the Holocene. In this poster, I will review the background and potential for this approach in southern Australia and outline my research objectives for the coming years.

# Classification Scheme for Quaternary Source Bordering Sand Dunes Based on Sediment Characteristics

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Many sand body sites in the Sydney area have been hypothesised as possible source bordering dunes (SBD) that were deposited and reworked during the Quaternary. These sand bodies are important as they contain artifacts significant to Aboriginal history. With a lack of sediment analysis into these sites, the landscape history remains a question for archaeologists. This work will aim to explore the possibility of using particle size distribution (PSD) to test for a characteristic signature for SBD. To achieve this, samples from different origins were compared based on sediment size, sorting and skewness. This includes fluvial deposits, desert dunes and known SBDs. The aim is to use this dataset to classify the unknown SBD samples. Initial results indicate that each site has a unique distribution, even between neighbouring sites. However, all aeolian sites are characterised by a dominant sand mode that is well sorted. The amount of silt and clay often increases with the age of the sample, making it difficult to compare between buried aeolian and fresh fluvial deposits.

# Quaternary landscape evolution in the arid interior of Northern Cape, South Africa

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Affiliation/s

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The arid interior of southern Africa potentially provides a long record of landscape evolution since at least the Neogene. Typical landforms include deflated surface gravel pavements and dunes, megafans derived from mountain fronts, weathered bedrock inselbergs, colluvial slope sediments, underfit ephemeral river channels, and ephemeral pans. Most of these landforms are largely relict under today's conditions. In order to understand arid landscape evolution during the late Quaternary, we recorded ~3 m of subsurface sediment stratigraphy within excavated trenches at the Vaalputs radioactive waste storage facility site, 120 km south of Springbok, Northern Cape, South Africa. This comprises <40 cm of present soil, composed of massive and unstructured medium sand with low (1.2-1.4%) organic content, overlying fractured bedrock (<2 m thick) containing chemical precipitates of sepiolite and barite along fracture planes, and both intact and broken up calcrete and silcrete duricrusts found at depth. Seven samples for luminescence dating were removed from the uppermost sandy soil. Ages vary substantially from 1.23±0.19 ka to 60.43±4.14 ka and spanning marine isotope stages 1 to 4. This range of ages and the nature of sub-soil precipitates suggests episodic land surface and subsurface development during the late Quaternary related to variations in moisture availability. Switches between arid-humid phases during the late Quaternary are similar to, but do not always chronologically match with, other proxies in the region. This may reflect climatological differences between mountains and interior lowlands, which are not well captured in regional climate reconstructions.

# Dating sediments from the Australian alpine Lake Albina

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Affiliation/s

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Recent work has called into question the accuracy of radiocarbon dating in alpine Australia (De Deckker et al., 2023). Here we examine 210Pb, 137Cs, and 14C (n=18) dates obtained from plant macrofossils, the pollen fraction, and bulk sediment samples from a 5.3m long core from Lake Albina (1900 m elevation) in eastern Australia. Bulk and macrofossil samples were analysed at the KECK AMS facility in the University of California. All bulk and macrofossil samples were treated with a standard Acid-Base-Acid procedure prior to combustion. The pollen fraction was extracted at Chronos, UNSW, following the laboratory protocol outlined by Turney et al., (2021). An initial age-depth model estimates a basal age of 19,300 cal yr BP with an average sedimentation rate of 0.26mm/yr. However, several age reversals highlight the difficulties of dating alpine sediments.

Data from 3 adjacent sediment core drives were aligned using Corelyzer, high resolution photos, X-radiograph images, and stratigraphic features. 210Pb dating of bulk sediment indicates an age of 1980 BP ±5 at 5cm depth, while dates from a macrofossil and the pollen fraction from the same depth returned ages of 111 and 550 cal yr BP, respectively. In older samples, macrofossil radiocarbon dates (n=7) caused two age reversals, with a Bayesian age-depth model excluding 3 of the dates, suggesting care is needed when selecting and dating macrofossils in the alpine zone. We suggest that intensive dating of sediments using a range of techniques including OSL where possible is needed to accurately construct age-depth models, especially in the alpine zone.

# Investigating South Pacific climate dynamics during the Holocene using multi-proxy stalagmite records (Atiu, Cook Islands)

Nikita Rohalskyi[1], Andrea Borsato[1], Silvia Frisia[1], Danielle Verdon-Kidd[1], John Hellstrom[2], Mohammadali Faraji[1], Quan Hua[3], Russell Drysdale[2]

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The South Pacific Convergence Zone (SPCZ) extends diagonally across the South Pacific and its displacement controls both rainfall variability and tropical cyclone activity. Little is still known about its responses to rapid climate fluctuations. Here we present a high-resolution, multiproxy study of two coeval stalagmites retrieved in Nurau Cave (Atiu, Southern Cook Islands) spanning the interval between 14,500 and 1,000 years BP, which offer the opportunity to investigate the strength and position of the SPCZ during rapid climate changes such as the Younger Dryas, the 8.2 ka and 4.2 ka events.

The two stalagmites are characterised by several growth hiatuses, low uranium concentration and high initial $^{230}$Th content, rendering the Uranium-series dating often challenging. Thus, we integrated petrographic observations, radiocarbon analyses and annual laminae counting to identify the position of hiatuses and improve the age model.

Previous studies on modern and active Atiuan stalagmites (Faraji et al., 2022, Quaternary Science Reviews, 289, 107633) demonstrated a relationship between stable isotope ratios, fabrics and infiltration, where more porous calcite fabric layers were associated with more negative $\delta^{18}O$ values and high infiltration. Similarly, the stable isotopes ratios and fabrics of two stalagmites from Nurau Cave are directly controlled by infiltration. During dry (low infiltration) periods, prior calcite precipitation (PCP) and evaporation caused positive shifts in both the $\delta^{13}C$ and $\delta^{18}O$ values. The stable isotope ratios are also strongly influenced by the aquifer dynamics, rendering a direct quantification of rainfall and infiltration from stalagmite $\delta^{18}O$ values alone (a rain signal) extremely difficult. This is highlighted by the comparison of other Holocene stalagmite records across the Pacific, where a negative relationship between rainfall amount and stalagmite $\delta^{18}O$ values is masked and/or overridden by other factors likely related to cave hydrology and shows stalagmite fabrics faithfully record a rainfall signal.

# Source-bordering linear dunes record post-LGM hydroclimate in Mithaka Country, northwest Kati Thanda (Lake Eyre) Basin

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Affiliation/s

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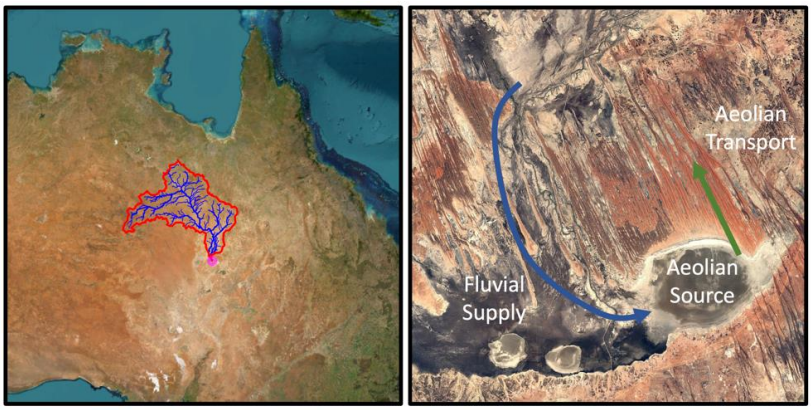
Mithaka country is home to a linear dune field located within the Channel Country of the Kati Thanda-Lake Eyre Basin. These dunes, emerging since the Last Glacial Maximum (LGM), are positioned downwind of Lake Machattie, which receives sediment from the Georgina, Burke and Hamilton Rivers. This geomorphological system serves as a valuable case study for investigating hydroclimatic variations post-LGM. The dune field relies on sediment delivered from runoff in a catchment that extends northward into a tropical climate (left graphic). However, for aeolian transport to develop the dunes, the arid interior lake must be dry (right graphic). We propose a "Goldilocks" hydroclimate for dune development, where intermittent lake filling provides optimal conditions; sediment supply is limited if the region is too arid and the lake is not replenished, or if it is too humid and sediment remains subaqueous. To test this hypothesis, we use the sedimentology and geochronology of cores in the lake delta, lake, and dunes. Dune cores reflect the elongation of linear dunes away from the lake at a rate corresponding to sediment flux, while lake delta and lake cores provide insights into the timing and amount of aeolian sediment supply. This study enhances our understanding of the complex geomorphic response to, and interpretability of, glacial-interglacial wet-dry oscillations in Australia's interior.



# Freshwater reservoir effect investigation for the lower and central Murray River

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Since the 1950s, archaeological research conducted along the lower and central Murray River, on Ngintait, Latji Latji, Barkandji, Yorta Yorta, and Ngaiawang Countries, has relied on radiocarbon dating of freshwater mollusc shell to help confirm the chronology of human occupation within this region as well as support larger models of human occupation timing within Australia. The popularity of freshwater mollusc shell for radiocarbon dating in this region is partially due to the prevalence of shell in a variety of Aboriginal cultural sites.

However, radiocarbon dating of freshwater organisms, such as molluscs, is complex as the carbon reservoir of the water bodies in which they live may differ from atmospheric values. Therefore, radiocarbon dates which do not consider this freshwater reservoir effect may be inaccurate.

While Gillespie and colleagues (2009) investigated the freshwater reservoir effect in the Murray-Darling Basin around Willandra Lakes World Heritage Area, the effect present in the Murray River has yet to be explored. Therefore, this research analysed historically live-collected freshwater mussel samples collected from Ngintait, Latji Latji, Barkandji, Yorta Yorta, and Ngaiawang Countries, near Mildura (VIC), Echuca (VIC), and Mannum (SA), to establish a freshwater reservoir effect for the lower and central Murray River.

The calculated average offset of approximately +136±8 years will have an impact on chronologically recent sites and improve overall precision. These results will help us improve chronologies in the region and better understand the important relationship between people, molluscs, and Country.

# A 5000-year history of New Zealand's climate through multiproxy stalagmite analysis

Lachlan Young[1], Andrea Borsato[1], Danielle Verdon-Kidd[1], Silvia Frisia[1], Mohammadali Faraji[1], John Hellstrom[2], Russell Drysdale[2], Adam Hartland[3], Jianxin Zhao[4]

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The Holocene climate in the Northern Island of New Zealand is less understood relative to that of the Southern Island, although majority of New Zealand population live on the Northern Island. Speleothems are a rich source of paleoclimate information in New Zealand, particularly in the Waitomo karst region. This project utilises an active stalagmite retrieved from Rumbling Gut cave (RG1) located in the Waitomo district, which spans continuously the last 5,000 years, as constrained by 30 U/Th analyses. The stable isotopes ratios and calcite fabric analyses allowed reconstructing a low-frequency climate record delineating wet and dry phases specific to the North Island of New Zealand. The RG1 stable isotope series was interpreted utilising established oxygen isotope rainfall relationships for the region, and subsequently compared to other New Zealand speleothem records.

Distinctive peaks in the carbon isotopes record highlighted abrupt environmental changes in the area, most notably during the 4.2 ka event and around the time of the European settler's arrival, which are here preliminary interpreted as related to changes in the vegetation.


# Friday 28th June

# Abstracts for oral presentations

# New investigations of the Clybucca - Stuarts Point midden complex in partnership with the Ngambaa Aboriginal Corporation

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The Clybucca-Stuarts Point midden complex (CSPMC) on the mid-north coast of New South Wales, represent one of the largest, if not the largest, temperate midden complexes on the eastern seaboard of Australia. Archaeological and geomorphological research during the 1970s suggests that these extensive midden lenses at Clybucca and Stuarts point may encompass the period of 9-3ka. At 9 ka the area around Clybucca became a large embayment sheltered by offshore barrier islands. Sea levels continued to rise steadily and peaked at c. 6ka. After 6ka it transformed into a coastal plain as the coastline prograded. This 9-3 ka period that CSPMC is argued to represent a time when Aboriginal society underwent significant social and economic change. While elaborate models have been proposed around potential drivers of this change, such as overcrowding on coastal plains as sea levels rose, significant gaps in research limit understandings. Thus, CSPMC may provide one of the most extensive and detailed records of Aboriginal activity along the coastal plain during this critical interval.

In partnership with the Ngambaa custodians, UQ has now undertaken three archaeological field schools documenting the site complex and together have begun to build a new story of this rich cultural landscape. This pilot research suggests that a combined archaeological and paleoenvironmental approach has the potential for a fine resolution sea level/climate record for this landscape, and a revised account of Aboriginal resilience in response to the challenges of climate shifts in the Holocene.

# Testing the Dark Emu hypothesis: archaeological and palaeoecological research in Mithaka country

Michael Westaway[1], Patrick Moss[2]

Affiliation

[1]University of Queensland, [2]Queensland University of Technology

The book Dark Emu created an enormous amount of public debate around how we should think about the Aboriginal past. It provides an excellent opportunity to raise the profile of archaeological and palaeoecological research in Australia, but curiously the methods required to test its ideas are not much applied in Australian archaeology (Westaway et al 2023). The ethnohistory of Mithaka country has revealed that it is a landscape where Aboriginal people lived in villages and intensely harvested native grasses and practiced what could be defined as aquaculture. We outline the multidisciplinary research that has been undertaken to investigate how the Mithaka managed their environment in one of the world's last unregulated desert channel systems.

# Geological controls on the preservation of hominin presence on the modelled route through SE Asia

Louys, Julien[1]; Kealy, Shimona[2]; Zaim, Yahdi[3]; Rizal, Yan[3]; Aswan[3]; Puspaningrum, Mika R.[3]; Hascaryo, Agus T.[3]; Shidqi, Benyamin P.[3]; Price, Gilbert J.[4]

Affiliation/s

[1] Griffith University; [2] Australian National University; [3] Institute of Technology Bandung; [4] The University of Queensland

We present least-cost modelling efforts to trace the most likely path of migration for hominins, including likely human ancestral species and modern humans, from mainland Southeast Asia to Java. The most likely routes take place through the now sunken Sunda Shelf, however, modelling under different sea-level conditions suggests that the Riau Archipelago and the peneplains of eastern Sumatra may have been favoured during high sea-level conditions. Ground-truthing these models through surveys undertaken on foot through the offshore islands east of Sumatra as well as in the low-lying plains east of the Barisan Mountains illustrates the difficulties in finding fossil and archaeological material in these regions. In the Riau Archipelago, the largely Mesozoic plutonic outcrops are unsuitable for either lithic production or preservation of fossils. Our surveys revealed some archaeological finds, but most appear to be quite recent. In eastern Sumatra, the migration routes coincide with landscapes that represent net erosive regions, are highly susceptible to chemical erosion and pedogenesis, host relatively few outcrops, and largely overlaid with marine sedimentation. In future, the search for early evidence of hominin migrations might need to target the underwater regions of the sunken Sunda Shelf.

# Megafauna amongst the mangroves: a mass death assemblage of giant Pleistocene marsupials in the Pilbara, Western Australia

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Affiliation/s

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Despite what you may sometimes read, the definitive cause behind the loss of Australia's Pleistocene megafauna remains uncertain. Although there has been an increased focus on megafauna in recent decades, few species have reliable dates or a comprehensive understanding of their palaeobiology, palaeoecology, and distribution—criteria essential to test leading extinction hypotheses. While numerous fossil-bearing sites are known, few have been thoroughly investigated. In a collaborative project initiated by the Western Australian Museum and supported by Citic Pacific Mining, we recently revisited the fossil deposit at Du Boulay Creek, near Mardie in the Pilbara region of Western Australia. This deposit is recognised as containing the most westerly occurrence of megafauna on the continent yet has not been extensively investigated. Our recent work there has revealed a mass death assemblage of marsupials, including numerous articulated skeletons of the giant megaherbivore, *Diprotodon optatum*, as well as other extinct marsupials. Among the vertebrate remains, numerous rhizoconcretions have been observed, including both laterally extensive root casts and moulds of what appear to be pneumatophores (vertical aerial roots) of mangroves. From the vertebrate fossil-bearing strata, we have also recovered numerous molluscs including mangrove whelks (*Terebralia palustris*), telescope snails (*Telescopium telescopium*), oysters (Pteriomorphia), crabs (Brachyura), and tube worms (Sabellida), supporting the inference that the deposit accumulated in the intertidal zone. This is the only fossil assemblage of its type known to contain the remains of large-bodied terrestrial vertebrates that were accumulated in a mangrove ecosystem, at least on the continent; its formational process is still under investigation. Our preliminary dating suggests a Late Pleistocene age for the remains. The fossil-bearing strata is approximately 4 metres above modern mean sea level, and mangroves no longer occur proximally. The loss of local mangrove habitat may be the result of changes in Quaternary sea levels and/or potential tectonic uplift.

# A revised chronology and depositional history for the Outer Arumpo lunette, Willandra Lakes Region World Heritage Area, NSW

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Affiliation/s

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Quaternary research within the Willandra has focused heavily on understanding the record of landscape change preserved within the Lake Mungo lunette. However, Mungo is just one of the 13 major lakes that comprise the Willandra and, unique among its neighbours, is not directly fed by inflow from the Willandra Creek. The outcome is a biased view of landscape change centred upon one, terminal lake within the system.

The stratigraphic record exposed within a deflationary hollow on the Outer Arumpo (OA) lunette, known as Top Hut 1, has been revisited as part on an ARC DECRA project. Here, Bayesian modelling of 52 new single-grain OSL ages, accompanied by a sediment micromorphological analyses, has been used to construct a chrono-stratigraphic framework for lunette development across 7 identified stratigraphic units. The OA basin filled ~80–56 ka ago (Unit 2), with high lake levels maintained until ~44 ka ago (Unit 3). Relative lake level declines ~43–41 ka ago (Unit 4), before fluctuating rapidly ~40–38 ka ago (Unit 5). None of the sediments sampled within the TH1 site date between this 38 ka age and ~150 years ago (Unit 6 and 7).

These findings demonstrate that Lakes OA and Mungo have distinct hydrologic histories. The alternating sedimentology of Unit 5 indicates that Lake OA was fluctuating rapidly while Lake Mungo was relatively full and stable ~40–38 ka ago. Critically, these Unit 5 sediments correlate to the 'Arumpo Unit Type Section' of Bowler (1998) located ~400 m south of TH1, making the Arumpo Type Section significantly older than the 'Arumpo-aged' deposits of the Lake Mungo lunette (~25–18 ka). This conclusion demonstrates that the stratigraphic scheme developed for Lake Mungo is not applicable to other lake basins in the system, given the unique hydrologic and depositional history of each basin.

# Stratigraphy of a Late Quaternary Low-Angle Fan-Delta Complex, Lake George basin, NSW

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Affiliation/s

[1] Australian National University

The Lake George Basin, NSW, boasts an unparalleled sedimentary record spanning nearly 4 million years, making it a unique terrestrial depositional system in Australia. Historical observations document fluctuations in lake water levels since 1820, ranging from completely dry to maximum depths of 7 metres. Older shorelines, up to more than 30 metres above the present lake floor indicate past highstands that were significantly above historical levels.

This study focuses on a low-angle fan-delta complex exposed within the Bungendore Sands Quarry, located within the lower Butmaroo Creek catchment. Butmaroo Creek and the Bungendore Sands Quarry provide unique insights into the sedimentary architecture of humid fan systems. Exposures reveal diverse deposits including point-bar, overbank, aeolian, beach, and clay drapes.

A comprehensive facies model was constructed, based on detailed logging and description of outcrops. Chronology comes from optically stimulated luminescence (OSL) and radiocarbon dating.

Deposition of a lower, fluvial sequence began at or prior to 55 ka BP (radiocarbon years; Marine Isotope Stage 3). Despite being within the range of historic lake levels and below the height of paleoshorelines, lacustrine sediments are conspicuously absent in this lower sequence. Lacustrine sediments deposited during early Marine Isotope Stage 3 appear to have been removed by fluvial reworking following a fall in lake level. The transformation of a metre-thick sequence of lacustrine sediment into a mud-boulder conglomerate is evidence of this reworking.

The findings from this study highlight the interplay between fluvial dynamics and lacustrine sedimentation in humid fan systems, offering valuable insights into the rarely studied architectural features of such depositional systems.

# Characterising Morphologic Change Within a Distributive Fluvial System – a Case Study of the Lachlan River, SE Australia

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Affiliation/s

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Within the Murray-Darling Basin (MDB) of south-eastern Australia there is a variety of westerly draining alluvial river systems, comprising an array of complex distributive fluvial system (DFS) surfaces. Many of these rivers exhibit drastically different spatial, morphologic, and sedimentologic characteristics between their present channel forms and respective palaeochannels, with such differences being attributed to varying climate, and hydrology throughout the late Quaternary. Such palaeochannel networks are thought to reflect a vastly increased runoff regime in the late Pleistocene, which has declined with the onset of the Holocene until the present regime which is characterised by declining channels and extensive floodplain wetlands. Located on the southern riverine plain of NSW, the Lachlan River DFS is of particular interest, due to the preservation of a number of uncontextualised palaeochannels that vary both spatially and morphologically across the DFS surface. This study aims to delineate the Lachlan River distributive fluvial system through systematic mapping of palaeochannels, alongside temporal (optically stimulated luminescence dating) and sedimentologic analysis of key channels across the palaeochannel network, concentrating on the Holocene transition to the modern river system. Preliminary results indicate a shift in sediment regime from sandy, bedload dominated palaeochannels, to mixed load and suspended load dominated, whilst digital elevation model derived morphologic analysis suggests a wholesale threshold response from throughgoing, maintaining channels, to throughgoing, discontinuous, declining channels.

# Updating the ‘Glacial Map of Tasmania’

Roberts, Nicholas J.[1]

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Tasmanian landforms and deposits bolster Earth’s limited direct records of late-Cenozoic glaciation at mid-southern latitudes. Their latest compilation – the 1965 *Glacial Map of Tasmania* – presents knowledge that is now at least 60 years old and strongly influenced by two contemporary factors: early aerial photographic surveys had only recently provided the first ubiquitous observations of Tasmanian landscapes; additionally, the widely held view that Tasmania experienced just one Quaternary glaciation dissuaded temporal differentiation of features. Systematic revision of Tasmania’s glacial mapping is warranted given expanded geologic surveys across the state, globally distributed evidence of repeated Plio-Pleistocene cool periods, and innumerable Quaternary science advancements. Mineral Resources Tasmania is updating and expanding statewide glacial geology and glacial geomorphology mapping to include progress since 1965. Diverse geochronologic approaches now differentiate seven late-Cenozoic glacier advances spanning at least six glacial-interglacial cycles, although many more likely occurred. New exposures and bare-earth LiDAR reveal deposits and landforms missing from former mapping and help critically evaluate the glacial origin of previously reported features. The updated mapping uses GIS-compatible relational databases that can be easily adjusted to reflect new and revised knowledge, thereby optimising functionality. Beyond identifying geographic, chronologic, and thematic gaps in documented glacial features, Tasmania’s modernised glacial map is helping reform the state’s Cenozoic chronostratigraphic framework.

# Long-term stability of the northern Antarctic Peninsula ice sheet

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The Antarctic Peninsula is one of the most climate sensitive regions and has experienced dramatic ice loss in the last few decades. Warming during the last few decades is responsible for the collapse of two of its ice shelves and continued retreat of a further six. The Antarctic Peninsula Ice Sheet (APIS) can release ice to the ocean rapidly via ice streams and makes an important contribution to sea level change. Despite these recent changes, the long-term sensitivity of the APIS to climate change is poorly constrained. In this paper we present new exposure ages using $^{10}$Be, $^{26}$Al and $^{21}$Ne from nunataks from a transect across northern Palmer Land. We find exposure ages of more than 1 million years for Mt Faith and Mt Sullivan, which correspond to very low rock erosion rates. We compare the results with ice sheet modelling and glacioisostatic adjustment studies to determine likely thinning of the ice sheet during global warming at the end of the Pleistocene.