VOLUME 37 | NUMBER 1 | JULY 2020

Quaternary AUSTRALASIA

Alaska

Falkland Islands

Timor-Leste

THE ANTHROPOCENE VS COVID19

(by Anne O. Nimmos)

If there's one thing worse than COVID19
it's the coming scourge of the Anthropocene.
Let me explain to you what I mean.

It seems us humans have the Earth outgrown
Meriting a geological epoch all of our own
But do we know what seeds we have sown?

An epoch where we're in charge at last
Total domination – forget the past!
But we know that epochs never last.

So thanks to some intelligent boffin
We've stuck a nail in our own coffin,
Something that you shouldn't do often!

Those ambitious profs in their ivory tower
Thought the idea bold, so full of power
And fresh and new like an unfurling flower.

Even before it's started I'm getting cold feet,
The Anthropocene might not be so sweet
Even though we sit in the driver's seat.

Yes this technological age will bring
Great progress as new ideas take wing,
Oh think how the cash registers will ring!

But there's no coffee there
And the temperature of the air
Is more than any of us can bear.

Every time we put past behind us
Our old mistakes come back to bite us,
Can we really carry on regardless?

Perhaps we should think about turning back
Or taking a completely different tack –
Get the Earth and ourselves back on track.

Here's an idea from this great Timeless Land
The Everynow – doesn't that sound just grand?
The past and present together hand-in-hand.

Let's give it a go, now's the right time,
The Everynow could be so sublime
And definitely better than this rhyme.

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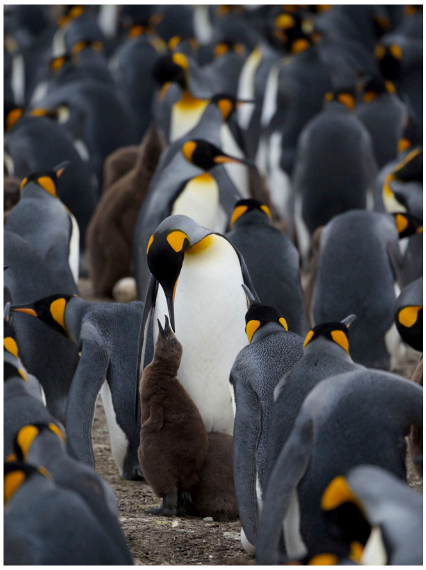
CONTENTS



Front cover photo:

King Penguins, Falkland Islands.
(Photo credit: Chris Turney)

Below:

Peter Almond sacrificing himself to the black flies in deepest, darkest Alaska.
(Photo credit: Tim Barrows)

Errata:

The photograph on page 3 of the December 2019 issue of Quaternary Australasia was incorrectly credited and the location was incorrect. If anyone knows the location and the photographer – the Editors would be grateful to know.

EDITORIAL

Dear Quaternarists,

AQUA President Tim Cohen summed it up in his President's Pen this edition, when he said that the global pandemic has changed the face of many aspects in our lives.

Apart from the strange working environment, the sad loss of jobs, livelihoods and in some case lives of people we have know professionally and personally – it is the restrictions on travel that I selfishly feel most strongly about.

We have all been privileged to travel and experience the world as those before us never did. I returned from a dream hiking trip to Patagonia in late February – just before the boarders closed in both Australia and South America. I look at my photos from that trip and feel sad that my global travelling not only has been forced to stop – but also with guilt that perhaps I should now be looking at this travel as a privilege that I took for granted, and assess it in terms of what it was doing to our planet and its people.

More than ever – our research into the Quaternary is important. Professionally we have to ensure our work is relevant and robust and that its contribution to the future of our planet is acknowledged.

In this edition of Quaternary Australasia there are many excellent articles.

Tim Barrows (Alaska) and Zoe Thomas (Falkland Islands) report on their amazing trips to opposite ends of the world – and contribute beautiful photography to illustrate.

Patrick DeDekkers article on Lake George is a revised timely snap-shot into past environments in this region. Guest book reviewer Anne-Marie Tosolini provides her glowing praise for a book on the History of Plants by Paul Kendrick – which make me want to buy the book. Larissa Schneider provides a field report on her work on changing climates in Timor-Leste.

Kelsie Long relates her experience in Science Meets Parliament. Kelsie also shares her working from home experiences with some handy hints, and Anne O. Nimmos shows us her sense of humour in these times when we most need one.

I finally encourage you to read the thesis abstracts of our up-and-coming Quaternary scientists and to encourage them in their further research careers.

Yours Quaternarily,

Sanja Van Huet and Carol Smith
Co Editors

Below Left: Laguna de los Tres at the foot of Mt El Chalten, Agentina.
(All Photos: Sanja Van Huet)

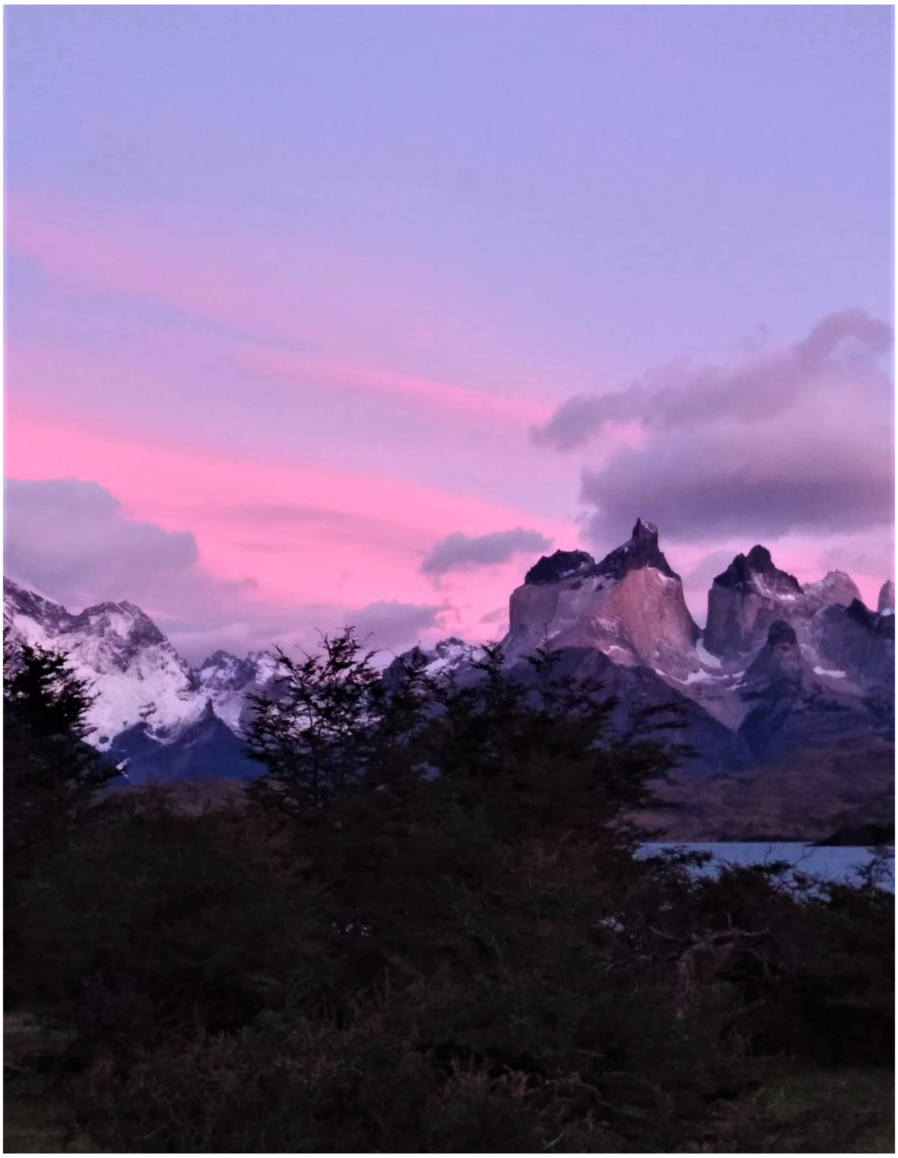
Below: Laguna Torres and Grande Glacier with massive tillite mounds, Argentina.

PRESIDENT'S PEN

Dear fellow AQUA members,

Welcome to the COVID edition of Quaternary Australasia! Autumn and winter have heralded a hugely different world since the last edition of QA in late 2019. Indeed a global pandemic has certainly changed the face of many aspects of our lives over the last three months. Many lives lost, a global recession and a short to long-term loss of livelihood have set the scene for a very different existence for many. Australian universities are scrambling to assess the damage caused by the decline in international students. Indeed the long term reliance by universities on international students and their fees have highlighted the fragility of this business model. Staff across the tertiary sector are madly delivering online content whilst being encouraged to take salary cuts and/or face the reality of re-structures and job losses. Certainly grim times for staff and their graduates. On the AQUA home front we decided to postpone the 2020 AQUA conference until 2021 but thankfully online events such as the online EGU and the AQUA e-pop-up conference have kept us engaged with the broader scientific community. Thank you to all the AQUA 2020 conference organisers for taking the baton forward to 2021 and thanks also to Chris Moy and Helen Bostock for the impromptu organising of the online get together.

Tim Cohen
AQUA President



Above: Hiking on the Perito Merino Glacier. Argentina. (All Photos: Sanja Van Huet)

Right: Morning view from campground Torres del Paine NP Chile. Picture is untouched .... It is impossible to take a bad picture!

NEWS

SCIENCE MEETS PARLIAMENT 2019

Kelsie Long

School of Culture, History and Language, Australian National University, Canberra, ACT, Australia

In 2019 I put my hand up to represent AQUA at the annual Science Meets Parliament (SmP) event in Canberra (26-27 November). This event has been attended by a range of AQUA members in the past including Professor Brad Pillans and Emily Field in 2017, Claire Krause 2015, Stephanie Kermode and Jessica Reeves 2012 and Lydia Mackenzie, Kirsty Wilkes and Patrick Moss 2011. I very much recommend checking out their reports in previous issues of QA. I was very excited to join this illustrious list of past attendees and to learn as much as I could about the political heart of the nation and how best to engage with it; but first a bit of background.

Science Meets Parliament began in 1999 as a way of bringing together decision makers and Australia's leading STEM professionals to promote the role of science, technology, engineering and mathematics in policy development. It is organized by Science and Technology Australia (STA) (https://scienceandtechnologyaustralia.org.au/), an organization that connects scientists with business, policy and each other through a range of initiatives and events. STA represents the interests of members when advocating with government, engaging industry, interacting with the scientific and technological community and communicating with the public. The SmP event runs over two days and the major highlight (apart from the rather delicious and fun SmP dinner, MC'd by Science TV show "Scope" presenter Lee Constable) is the meet and greet with a real life parliamentarian which occurs on the second day.

The first day featured a keynote from Professor Fiona Wood, a highly skilled plastic reconstructive surgeon and world leading burns specialist. She is best known for developing "spray on skin" with colleague Marie Stoner. Professor Wood spoke about how "today's comfort and convenience is yesterday's magic" and highlighted the importance of science communication, not just of the flashy discoveries but the everyday "boring" results. Every result matters. "Just because it isn't Haley's Comet doesn't mean it isn't important to someone".

Dr Alan Finkel, Chief Scientist and Professor Gary Evans; New Zealand chief science advisor, spoke on how to have input into policy and build connections. Dr Finkel spoke about hydrogen-based fuel and how he was able to get better traction with politicians by pitching the idea at

Far Left: Selfie in front of parliament house. (All Photos: Kelsie Long)

Left: Awesome nametag (tricky to accurately represent fish otolith research in Quaternary science using the sticker options but I did my best).

Above: Professor Fiona Wood speaking at Science meets Parliament, 2019.

the economic and export potential, domestic use and minimizing of emissions rather than coming in with a bunch of graphs. They both highlighted that it is most important to listen, to find out what is important to the Minister or member of parliament that you are speaking to.

Following these talks was a networking session hosted by Sally-Ann Williams from Cicada Innovations and Dr Zoe Doubleday, University of Adelaide. This session highlighted how science communication and networking is about 'getting the violin player out of the soundproof room'. They gave us a few strategies for pitching research, including the problem pitch:

"What I do is…(mission), The thing about this work is… (challenges faced), What I could really use…(the ask)" and the Solution Pitch: "You know how…Well what I am looking into is…I could really help with… What I could really use is…".

The facilitators emphasized in particular that, when you end on your "what I could really use", the major caveat is DON'T ASK FOR MONEY!

This session made me think about what I could really use in my work. I had come to Science meets Parliament with no agenda or expectations, except to listen and learn. My advice to anyone going to similar networking type events in the future would be to think about what specific things you want to get out of it. It could be networking with specific people who are attending, it could be establishing connections with museums or industry, it could even just be asking "Hey, does anyone have any sediment cores/ fish/shells/water samples lying around from this specific region". You never know, a new collaboration could be forged through such enquiries.

On the second day myself and the rest of my allocated group met with Ms Alicia Payne Member for Canberra with the Labor party, elected in 2019. It was Ms Payne, her advisor, me, two other ANU researchers and one researcher from Defence. We didn't really have a plan for how we were going to pitch our research, we were all from different fields, myself from archaeology/Quaternary research but the other fields included genetics in Australian animals, AI/machine learning, minimising explosion effects on personal protective armor for Defence…a bit of a mish mash of topics. I did bring along an enlarged image of a sectioned fish ear stone (otolith), showing its age lines and some analytical spots, which went down well. It was surprisingly fun to talk about the use of otolith in fisheries research, for tracking migration of populations, and so on, as well as my use for them as archives of past environmental change. Our chat was cut short by Alicia being called to a parliamentary vote, but we did manage to snap a quick group photo.

Above: Group photo with Alicia Payne MP (photo sourced from Alicia Payne's twitter feed)

Right: The giant Lego parliament house. (Photo credit: Kelsie Long)

The SmP event ended with farewell drinks in front of a slightly smaller but still very impressive version of Parliament House, this one made entirely of Lego!

My main takeaway from the two days was that science and research is not just about sitting alone in a lab or an office generating data, writing up papers and drinking coffee…some of it is that but it is also about forging connections with other researchers, with policy makers, industry and funding bodies. If nothing else these two days showed me how important it is to be able to synthesise what I do and why it is important for a range of different audiences.

My attendance at Science meets Parliament would not have been possible without the generous support of AQUA and the ARC Centre of Excellence for Australian Biodiversity and Heritage (CABAH) and I would like to thank them for this opportunity.

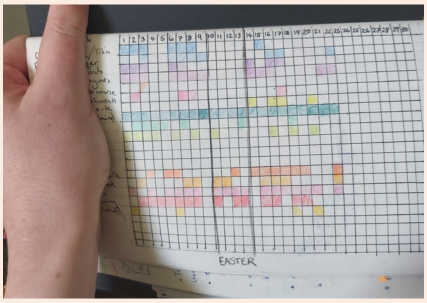
WORKING FROM HOME

Kelsie Long

School of Culture, History and Language, Australian National University, Canberra, ACT, Australia

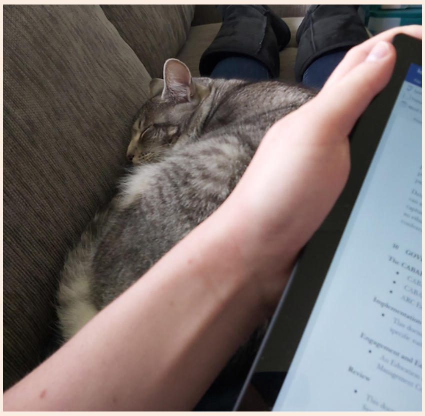
I found the first week of working from home really difficult. A lot of projects I had been working on were postponed, cancelled or not feasible in the current isolated world.

At the start of April, I began a Task Tracker of key things I wanted to achieve each day (or at least more regularly than I currently was). This helped me to regain focus and to feel like I had accomplished something each day (colouring in a tiny square was surprisingly satisfying). It helped me to get back on-track with work and writing and everything! I have since established new projects to work on and new collaborations, as well as cleaning up and hopefully publishing some work from my PhD. I am also getting on well with my new co-worker (although she isn't very good at respecting personal space!)



Above: Task tracker (Photo credits: Kelsie Long)

Below: The new co-worker



COLUMBIA GLACIER EXPEDITION ALASKA

Timothy Barrows

School of Earth, Atmospheric and Life Sciences, University of Wollongong, NSW, Australia.

School of Geography, Environment and Geosciences, University of Portsmouth, UK.

In June of 2019 I led a small expedition to the Columbia Glacier in a remote part of Prince William Sound, Alaska. The project is funded by an Australia Research Council Future Fellowship. The aim of the research is to better understand the tidewater glacier cycle in recent geological history. I was accompanied by Peter Almond (Lincoln University), Greg Wiles and Nick Wiesenberg (both from The College of Wooster). I was looking at the glacial geomorphology, Peter was the resident soil scientist and woodsman, Greg was the dendrochronologist and Nick provided logistical support.

We chartered a vessel to take us into Columbia Bay and set up camp on the eastern side of the fjord.

Previous Page: Timothy Barrows (Photo credit Greg Wiles)

Above Left: Columbia Glacier from the Great Nunatak (All Photos: Tim Barrows, unless stated)

Above: Ice eroded bedrock 'whaleback' and Peter Almond for scale

Left: Skiff and Peter Almond and Nick Wiesenberg

Below: Glaciers in the west arm of Columbia Bay, Alaska.

See also page 31

Our camp site was under 170 m of ice in 1980 and the glacier has since retreated more than 20 km. Each day we took an aluminium skiff out to a site along the fjord.

Most of the time this trip was without incident, but some large recent calving events meant the fjord was flooded with icebergs, which required some occasional creative manoeuvring. A huge tidal range also meant we had to be mindful of where we left the boat.

The Tatitlek people gave us permission to take samples on their country. Alder tree colonisation over the last 40 years has created an impenetrable barrier in some parts of the fjord, so we had to use creeks and gulches for access. Grizzly bears and wolves have also returned to the area, but these tend to give people a wide berth. By far the worst obstacle we faced were tiny black flies which followed us everywhere. These even tested our Kiwi colleague's patience to the limit, despite his adaptation to sandflies. We logged soil chronosequences, collected rock samples for surface exposure dating, wood samples from both buried fossil and living trees, and shells from bulldozed glaciomarine till to date glacier positions in the past.

We had unusually warm weather in late June, which was the second warmest on record. In July, Alaska set all time weather records with temperatures 10-15 °C above average. A pall of smoke hung over the fjord as we left as fires raged in other parts of the state. The increasing temperature from global warming is thinning Alaskan glaciers, which in turn are contributing to sea level rise. For the remainder of the project we will model the retreat of the glacier in the warming since the Little Ice Age and run a weather forecast model at 3 hourly intervals to understand prevailing weather conditions since 1830.

Top: Terminus of Columbia glacier 100 years later (Photo credit: Greg Wiles)

Middle Left: Tim Barrows and Nick Wiesenberg collecting a rock sample (Photo credit: Greg Wiles)

Above: Greg Wiles sampling a little ice age fossil tree (Photo credit: Tim Barrows)

Left: Spectacular glacial erosion in the upper fjord (Photo credit: Tim Barrows)

Below: Harbour seal on the brash ice (Photo credit: Tim Barrows)

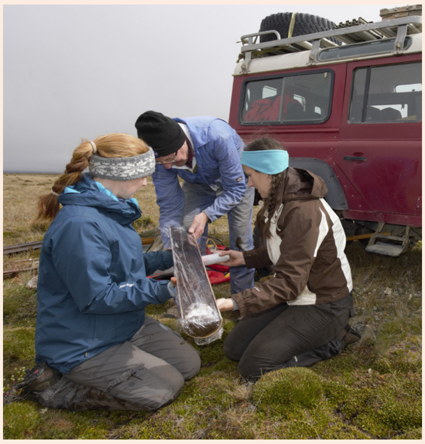
WHAT CAN PEAT TELL US ABOUT THE PAST AND FUTURE CLIMATE OF THE FALKLAND ISLANDS AND WIDER SOUTHERN OCEAN REGION?

Zoë Thomas, Haidee Cadd and Chris Turney

School of Biological, Earth and Environmental Science, University of New South Wales, Australia

We arrived in Stanley, capital of the Falkland Islands on February 29th 2020, totally unaware of the coronavirus-chaos that would soon hit the world in just a couple of weeks. Under the DECRA research project (DE200100907) funded by the Australian Research Council awarded to Dr Zoë Thomas, our fieldwork goal was to collect peat sediments from across the Islands to better understand the past climate and environmental history of the islands and the broader Southern Ocean region. Situated in the core of the southern westerly wind belt in the South Atlantic, the Falkland Islands (51-52°S) lie in an ideal location to investigate changes in atmospheric circulation over time. This field campaign was led by Dr Zoë Thomas, Prof. Chris Turney and Dr Haidee Cadd, working closely with Dr Steffi Carter from the South Atlantic Environmental Research Institute (SAERI) in the Falkland Islands.

One of our specific aims in this project is to develop highly-detailed reconstructions of southern westerly airflow during key periods of change over the Holocene. To do this we will examine wind-blown material that gets trapped in the peat bogs as they form over thousands of years. Dust from South America, with a different chemical signature to the geology of the Falklands, and exotic tree pollen from Patagonian forests are two particular proxies that we will investigate in detail. Using the new Chronos ^{14}Carbon-cycling facility at the University of New South Wales, intensive radiocarbon dating will allow precise alignment



Left: Dr Zoë Thomas, Dr Haidee Cadd, and Prof. Chris Turney with volunteer scientists Kapil Jiwa, Joanna Zanker and Susan Rutherford. (Photo credit: Neil Golding.)

Above: Dr Zoë Thomas, Dr Haidee Cadd and local guide Tony Heathman wrapping a peat core at Cape Carysfort. (Photo credit: Chris Turney.)

Below: Dr Zoë Thomas, Prof. Chris Turney, and local residents Robert Short and Jo Turner, looking at a peat core from Penguin Valley, Weddell Island. (Photo credit: Haidee Cadd.)

of our proxy reconstructions with a network of palaeoclimate records to test the timing, drivers and impacts of circulation change across the Southern Ocean.

On March 1st, the Islands experienced a beautiful late summer day, with temperatures hitting 22°C. We took the opportunity to drive around the East Island to get a feel for the landscape and take in the beautiful scenery. Our relaxing start did not last long and 3 weeks of intensive peat coring ensued.

We owe tremendous thanks to our SAERI collaborators, all the landowners who kindly gave us permission to take peat samples, and our local drivers who expertly navigated the camp terrain. Kidney Island (a small, tussac-covered island) and Weddell Island (the third largest island of the Falklands archipelago) were two highlights of our trip, due in part to the amazing volunteers that joined our sampling expeditions. The fast accumulating tussac peat on Kidney Island will be very interesting to compare to the slower accumulating peat that we found just below the summit of Mount Weddell.

Figure 1 shows locations from which we collected peat samples. In some of these locations, peat cores were taken down to the bedrock (the maximum depth we recorded was 6 m in Cape Carysfort). To do this we used a Russian D-section corer, allowing us to collect a series of 1 m length half cylinder sections of peat. Our local guide helpfully pointed out that we had probably collected as much peat on ourselves as we had in the tubes – peat sampling is not exactly clean work, but peat-cutting for fuel has a long tradition in the Falkland Islands, so they do know a thing or two about it! In other locations just a small sample of peat from the beginning of growth was taken. We managed to visit far more sites than we dared hope, somewhat due to the fantastic weather, landowner support, and enthusiasm of the volunteers that accompanied us.

The samples we collected are slowly making their way to Sydney on a ship and should be with us in a few months ready for analysis.

We left the Falklands in strange and sad circumstances, on the last flight out to Sydney via South America with borders closed and much of the world on lockdown. Although the conclusion of our trip was an unexpected end, it did not dampen the amazing 3 weeks we had in the Falklands and all the wonderful people we met along the way. We will be thinking of our friends in the Falklands and hope everyone stays safe and well over the coming months.

Figure 1: Image of all the locations we visited, and from which collected cores or basal samples. (Google Earth Imagery.)

This and previous page: Wildlife encountered during our trip. (Photo credit: Chris Turney.)

PALAEOECOLOGICAL RESEARCH IN TIMOR-LESTE AIMS TO REVEAL DEEP-TIME DYNAMICS OF TROPICAL CLIMATE AND THE HUMAN PAST

Larissa Schneider[1,2], Frederico Carlos Maria dos Santos[3], Helio Cassimiro Guterres[3], Simon Connor[1,2], Susan Rule[2,4], Michael Brand[2,5], Michael Bird[2,5], Simon Haberle[1,2]

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Editor's note: This paper is also to be published, in Portuguese, in the Timor-Leste Studies Association (TLSA) 2019 Conference Proceedings.

The independent nation of Timor-Leste is located at the southern margin of the Indonesian archipelago and is the largest and easternmost of the Lesser Sunda Islands. The region is influenced by monsoonal rainfall, characterised by a distinct wet-dry season cycle, making it susceptible to periodic and significant natural hazards. These include floods, drought, cyclones and fire, all of which present significant challenges to the people of the country and their environment (Burns, 2019; Molyneux et al., 2012). Timor-Leste has a long human history, being situated along one of the proposed routes for early human migration from Maritime Southeast Asia into Australia. Archaeological and palaeoecological evidence from this region has the potential to reveal early human-landscape interactions as people began to occupy island environments during the late Pleistocene (Kealy et al., 2018).

A critical question facing the current population of Timor-Leste is "how will global climate change affect moisture availability in this region?" We can begin to approach this question by examining how Timor-Leste's people and environment responded to climate changes in the past.

In June 2019 a group of researchers from Australia joined Timor-Leste colleagues to retrieve Quaternary sediment cores for palaeoclimatic and human impact studies in the lakes of Timor-Leste. This is a collaboration between the Instituto do Petróleo e Geologia of Timor Leste and the Australian National University, with participation of researchers from James Cook University and the University of Tasmania (Figure 1).

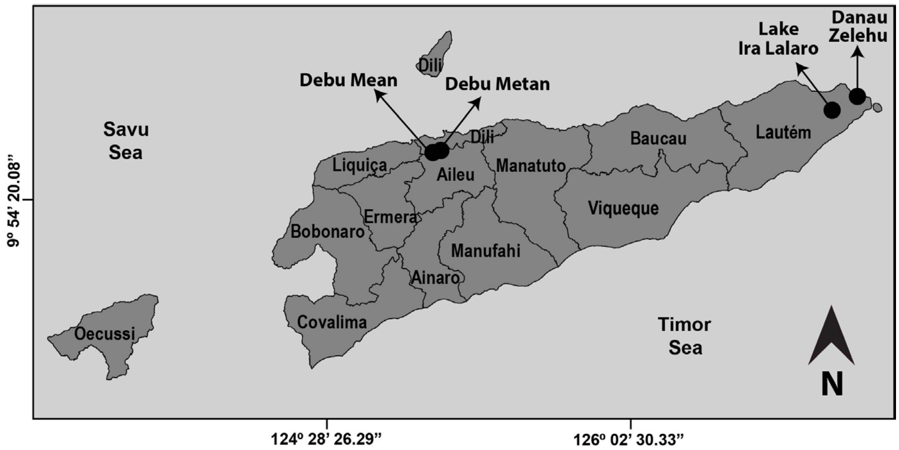
As part of a Centre of Excellence in Biodiversity and Australian Heritage (CABAH) initiative (https://epicaustralia.org.au/), these researchers are exploring environmental conditions from the time before humans first reached Timor, over 40,000 years ago (Kealy et al., 2018), through to the present.

One of the reasons Timor-Leste is so interesting from a paleoclimatic point of view is that it is situated

Figure 1: Researchers from the Instituto do Petróleo e Geologia of Timor-Leste, the Australian National University, James Cook University, the University of Tasmania and community members after a day the field in Tutuala, Timor-Leste.
(All photos: Larissa Schneider.)

at the nexus between three major climate phenomena: (i) the Indian Ocean dipole, (ii) the Asian-Australian Monsoon, and (iii) the El Nino Southern Oscillation (Turak and Devantier, 2012). Extreme weather events such as floods and drought put pressure on subsistence resources and exposes local communities to poverty and malnutrition (Barnett et al., 2007; Haberle et al., 2012). Reconstructing past climate changes in Timor-Leste is imperative to understand local climate drivers and the environmental responses, in order to develop mitigation measures to support local communities to overcome the negative effects of climate change.

To reconstruct the past dynamics of these climate drivers, a multi-proxy palaeoecological/climatological approach is necessary (Schneider et al., 2015). Sediment cores have been retrieved, for the first time, from a series of lakes located across Timor-Leste (Figure 2). A range of analyses, including geochemistry, pollen, charcoal, diatoms, ostracods, gastropods, seeds and fungal spores, will be used to identify climatic as well as human influence on landscapes of the past. Radiocarbon (^{14}C) and Lead (^{210}Pb) analyses will be used to date the sediments. Potential tephras from Indonesia may also support the chronology of the sediment cores.



Top - Figure 2: Map of Timor-Leste with the location of the lakes under study and Timor-Leste's 12 municipalities and special economic zone (Oecusse).

Figure 3: A photo of *Lantana camara* in Tutuala. This plant is native to tropical South America and has become a widespread invasive species in subtropical and tropical zones worldwide, including Timor-Leste.

MARKERS OF THE ANTHROPOCENE

In addition to the deep-time history of environmental and human interactions in Timor-Leste, our research aims to understand the ecological and geochemical changes in the more recent past, with a focus on markers of the Anthropocene (Schneider and Haberle, 2019). We expect to identify and describe the impacts of two periods of transition into the Anthropocene: the Columbian Exchange and the Great Acceleration. The introduction of plants from the Americas over 300 years ago, including Sweet Potato (*Ipomoea batatas*) and Cassava (*Manihot esculenta*), plus a range of weedy species (e.g. *Lantana camara* – Figure 3), have had a significant impact on human livelihoods and the ecology of Timor-Leste (Pannell, 2011).

Species introductions have undoubtedly altered local biodiversity, landscape integrity and food production. In addition the adoption of goat and banteng/buffalo herding, post – Portuguese colonisation, are likely to have increased nutrient concentrations (nitrogen and phosphorous) in soils and eutrophication of wetlands. These processes are recorded by geochemical and fungal proxies in lake sediments.

Mining activities in Timor-Leste are currently focussed on oil and gas extraction and construction materials, including sand, gravel, limestone and andesite (Hill and Saldanha, 2001). The potential for growth in the mining sector, in resources such as manganese, copper, chromite and gold extraction, is significant (Monteiro and Pinto, 2003) as the government moves towards enabling mining companies to operate under a Mining Code (Mining Journal, 2016). Geochemical studies are essential to provide baseline information on the regional geochemical signal prior to the establishment of a Mining Code in the country.

STUDY SITES

1) Debu Mean (Red Lake) and Debu Metan (Black Lake) (8.5986ffl S, 125.5997ffl E): These lakes were named after their water colour, caused by iron biofilm blooms during low water-level periods (Figure 4). Their small catchments and location at the edge of an escarpment make them sensitive to the dynamics of atmospheric vs. local catchment inputs in the geochemical signal. The lakes are situated on an ecotone between savanna-woodlands and woodland-rainforest ecosystems, determined by orographic rainfall.

Past vegetation dynamics and rainfall variability, driven by changes in the strength of the monsoon climate system, will be a focus of the palaeoecological analysis in these lakes. In addition, atmospheric mercury changes in the last 150 years will be investigated as a marker of the Anthropocene. Mercury is known to have increased by 3 to 5 times with the onset of the Industrial Revolution in the Northern Hemisphere (Fitzgerald et al., 2018) and with the onset of the Great Acceleration in the Southern Hemisphere (Stiton, under review). As Timor-Leste is located just below the Equator, it will be useful to determine how the anthropogenic mercury from both hemispheres has impacted the natural biogeochemical cycle of mercury at this site.

2) Lake Ira Lalaro (8.439575° S, 127.146844° E): Lake Ira Lalaro is the largest lake in Timor-Leste (British Geological Survey, 2007). The lake basin is composed of 'Poros' limestone approximately 20 m thick. This lacustrine limestone lies on top of the coralline Baucau limestone (Audley-Charles, 1965). At an altitude of 318 m, the lake has a surface area of 1900 hectares which varies seasonally, with the exposed lake bed used for grazing (Kuchling et al., 2007; White et al., 2006) at times of low lake level. Due to the high plant and animal biodiversity recorded around the lake and neighbouring tropical dry forests of the Paitchau Mountains, the area has been gazetted as the Nino Konis Santana National Park (Turak and Devantier, 2012) (Figure 5).

Above - Figure 4: View of Debu Mean (Red Lake), Municipality of Dili, showing the iron biofilm. (All photos: Larissa Schneider.)

Figure 5: Researchers paddling out onto Lake Ira Lalaro to core lake sediments for palaeoenvironmental reconstruction.

Carbonate-rich sediments to a depth of ~2.5m were retrieved from this lake and will provide insights into the long-term history of climate change and human impact in the region, particularly monsoon dynamics and rainfall variability.

3) Danau Zelehu (8.385917° S and 127.245916 °E): This lake lies on an uplifted coral terrace north of Tutuala (Figure 6). The lake is 33 metres above sea level and surrounded by rainforest with evidence of abandoned gardens and village sites (Figure 7). Colonisation (Portuguese and Indonesian) resulted in abandonment of some remote village sites in favour of settlements closer to government administration centres and road networks.

The shallow lake sediments are likely to reveal a history of recent human settlement and gardening practices in the lake catchment, followed by abandonment and regrowth of rainforest, a clear legacy of colonisation over the last three centuries.

CONCLUSION

Timor-Leste occupies a key position in the deep-time history of climate change and human migration between Southeast Asia and Northern Australia. Using sediments from both small and large lakes, our multiproxy analytical results will

Below - Figure 6: Danau Zelehu (circled) in Tutuala, Timor-Leste, as viewed from the Pousada Lautem.

Right - Figure 7: Constructed stone-walls under the rainforest canopy near Danau Zelehu represent earlier settlement patterns (abandoned gardens) near the modern township of Tutualu.

track the evolution of Timor-Leste's trajectory of past environmental change on both local and regional scales. These insights will provide an environmental context for the cultural exchanges that shaped Australia's past and a much-needed historical perspective on how Timor-Leste's ecosystems and societies might respond to the challenges of future climate change.

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MARKHAM RIVER FLOODPLAIN SEDIMENTS REVEAL LAST GLACIAL MAXIMUM EROSION IN PAPUA NEW GUINEA UPLANDS FOLLOWED BY LANDSCAPE STABILITY

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The Markham River drains a catchment of 12800 km^2 in northern Papua New Guinea and flows into the Huon Gulf south of Lae. The catchment extends from the Finisterre and Saruwaged Ranges in the north to the Ekuti Range near Wau in the south. Major tributaries are the Erap, Leron and Gusap Rivers from the north and the Bulolo and Watut Rivers from the south. The Markham River is braided where it flows across the broad floodplain of the fault-controlled Markham Valley.

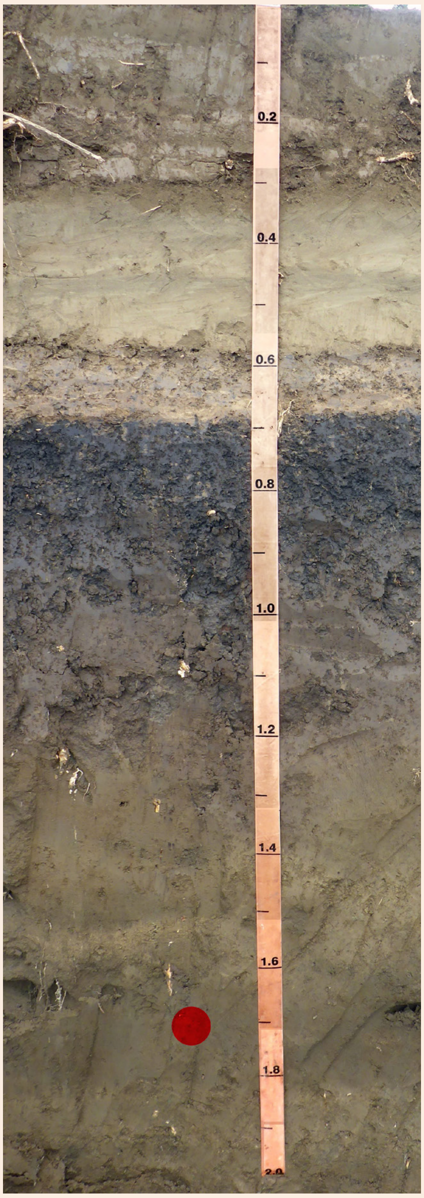
Palaeosols are prominent in the banks of the Markham River. Near the village of Ganef (146.6448°E 6.6266°S), situated 10 km southwest of Nadzab (Lae) airport, deep sandy sediments containing a very prominent clayey palaeosol (Figure 1). This suggests a period of rapid sedimentation on the Markham River floodplain, followed by a long period of organic matter accumulation, weathering and a low sedimentation rate, followed by renewed higher rates of sedimentation. The section was described (Table 1) and an undisturbed sample (WLL1401, Victoria University of Wellington, New Zealand) was taken from 1.7 m depth (see red dot in Figure 1) using an aluminium tube, in order to ascertain the age of the major sedimentation event by optically-stimulated luminescence (OSL). Blue luminescence was measured during infrared stimulation of fine grain (4–11μm) feldspar, using the Single Aliquot Regenerative method (SAR) as described by Murray and Wintle (2000).

Table 1: Profile description.

SOIL HORIZON	DEPTH (cm)	HORIZON DESCRIPTION (Australian Soil and Land Survey handbook, 3rd edition 2009)
AC	0–30 cm	Olive grey (5Y4/2) (moist) silty loam (25% clay est.) with bands of clay showing sedimentary layering (platy structure); weak strength; strongly developed angular blocky peds 20–40 mm diameter; common very fine and fine roots, few coarse and medium roots.
C1	30–46 cm	Olive (5Y5/3) (moist) loamy sand; very weak strength; single grain; few very fine and coarse roots.
C2	46–58 cm	Olive (5Y5/3) (moist) with 2 cm thick olive (5Y4/2) band at top of horizon; loamy sand; very weak strength; single grain; few roots of all sizes.
2ACB	58–70 cm	Olive (5Y4/2) (moist) silty clay (35% clay est.); firm strength; strongly developed subangular blocky peds 8–10 cm diameter; few very fine and fine roots.
3A1B	70–100 cm	Grey (2.52.5/1) (moist) clay (50% clay est.); firm strength; strongly developed subangular blocky peds 10–20 mm diameter; very few very fine, fine and medium roots, no coarse roots.
3B1B	100–120 cm	Very dark grey (2.5Y3/1) (moist) silty clay (40% clay est.) with 60% dark olive brown (2.53/3) mottles 8 mm diameter; very firm strength; weakly developed angular blocky peds 50–100 mm diameter; common very fine and fine roots, few medium and coarse roots.
3B2B	120–140 cm	Dark olive brown (2.5Y3/3) (moist) silty clay (25% clay est.); weak strength; very weakly developed angular blocky peds 100 mm diameter; few very fine and coarse roots.
3CB	140–160 cm	Light olive brown (2.5Y5/3) (moist) loamy sand; weak strength; single grain; very few very fine, fine and medium roots, no coarse roots.
4A1B	160–183 cm*	Olive brown (2.5Y4/3) (moist) loamy sand; very weak strength; single grain; few roots of all sizes.
4CB	183–250 cm	Brown (10YR4/3) (moist) silty clay (50% clay est.) with 40% olive (5Y4/3) mottles 10 mm diameter; weak strength; massive; few very fine and fine roots.

*OSL sample taken at 1.7 m.

Figure 1: The floodplain profile on the north bank of the Markham River at Ganep. Several palaeosols are visible and the four most obvious of these are described in the profile description (Table 1). The most prominent palaeosol (3A1b horizon) is that at 70–100 cm depth. The red dot marks the sample position for OSL dating, within the palaeosol (4A1b horizon) at 160–183 cm depth. (Photo credit: Peter McIntosh)



The external dose rate was determined on the basis of gamma spectrometry measurements.

The sands at 1.7 m depth (red dot) were OSL dated at 23 300±1900 years before present (2019) (Table 2).

Assuming complete resetting of the OSL signal in the sands at deposition (which is likely given the length of the Markham River and its turbulent flow) this date indicates that there was major erosion in the Markham River catchment during the Last Glacial Maximum (LGM) c. 24 000–18000 years ago, when the highest points of the Saruwaged Range were glaciated (Prentice et al. 2011) and seasonal snow melt and patchy vegetation cover in the higher parts of the catchment probably caused widespread upland erosion. The most probable sequence of events is that sediment derived from upland erosion accumulated at Ganef in regular floods during the LGM, but slowed or stopped in the early Holocene when upland areas were stabilised by forest cover. This allowed a well-developed carbon-rich soil to form (probably under forest vegetation), along with weathering of sediments to clays. The palaeosol was then buried by a resurgence of sedimentation, probably corresponding with vegetation burning and land clearing for European-style farming in the early twentieth century.

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Table 2: Water content, radionuclide contents, a-value, equivalent doses, dose rate and luminescence age.

LAB. CODE	WATER CONTENT (%)	U (ppm)	TH (ppm)	K (%)	A-VALUE*	DE (Gy)	DOSE RATE** (Gy/ka)	OSL AGE (ka)
WLL1401	25.2±6.3	0.80±0.10	2.43±0.06	0.93±0.02	0.06±0.03	31.65±1.07	1.36±0.10	23.3±1.9

*The a-value is estimated
**The total dose rate includes cosmic dose rate of 0.1544±0.0077Gy/ka

THE RECORD OF WEEREEWA – LAKE GEORGE WITH AN AMBIGUOUS DATING ISSUE

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Lake George in New South Wales has received much attention scientifically, starting with the seminal paper by Bob Galloway on Late Quaternary climates in Australia, who discussed the conditions that prevailed during the last glacial. Galloway concluded that conditions were much drier than today. Galloway (1965) also determined that disturbed gravels at one location on the shore of Lake George were the result of cryoturbation, therefore identifying severe cold conditions during the glacial period. Following from that, Coventry (1976) documented a record of lake filling, with beach ridges pointing to quite an extensive amount of water, up to 37 m during the late Quaternary. His findings were based on radiocarbon dates (Coventry, 1976) of charcoal samples. A subsequent paper by Coventry and Walker (1977) further discussed the geomorphological significance of the ancient shorelines seen at Lake George. The ages presented in those papers were not calibrated.

In 1982, De Deckker studied the upper portion of core LG2 taken at Lake George by Dr Gurdip Singh and colleagues at the Australian National University. An adjacent core LG4 had extensively been studied by Singh et al. (1981a) and Singh and Geissler (1985). The latter monograph established an extensive pollen record that generated much discussion because of the suggestion of the antiquity of humans in Australia and a long history of fire (see Singh et al., 1981b).

Based on ostracod remains and their known extant ecology, De Deckker (1982) was able to reconstruct salinity levels in Lake George spanning the last 60,000 years (not using calibrated ages). The data he presented generally followed the same water quality reconstructions established by Singh et al. (1981a), this time based on algal and spore remains. These lake level and salinity reconstructions have since been used extensively in the literature. However, it was found that the radiocarbon dates provided by G. Singh to P. De Deckker were not representative of all the dates for the two cores (LG2 and LG4) that had been obtained by the ANU team. Professor J. M. Bowler, who had studied in detail the sedimentology of core LG4, had identified several important issues that were eventually ignored by others. These were the presence of pedogenic carbonates and reworked sediments due to the shallow nature of the lake and also resulting from deflation during dry episodes.

The complete list of levels and samples which had been dated for Dr G. Singh are available in Singh and Geissler (1985) and reproduced in Table 1. Note that analyses were performed on both organics and carbonate fractions, always giving different ages for some of the same horizons. At the time of De Deckker's study, G. Singh had only provided a certain number of dates [listed in bold and italics in Table 1] which De Deckker (1982) used to reconstruct the lake history.

Since then, De Deckker in association with Mr J. Head from the ANU Radiocarbon Laboratory and Dr E. M. Lawson at ANSTO prepared new samples in 1994-1995 that consisted of cleaned ostracods (prepared by Ms A. Barrie) as well as extracted organics from the same levels in the core. These data were never published but are reproduced in Table 2.

The outcome is that there is evidence that groundwater fluctuation at Lake George severely affect(ed) the nature of the organic material, thus causing significant contamination and 'rejuvenation' of the organic matter, whereas the biogenic carbonates which were analysed and consisted of pristine shells of very fragile, transparent and thin ostracods belonging to the species *Limnocythere dorsosicula*. These had not been reworked nor had undergone diagenesis, otherwise they would have been broken and abraded. The ostracod dates clearly display very different ages from the organic fractions, and, consequently, place a query on the chronology of lake levels and salinities determined by Singh et al. (1981a) and De Deckker (1982). Hence, until a better constrained chronology is obtained, the lake level history should be placed on a 'back burner'. This applies also to the dates obtained by Coventry (1976) from charcoal sourced from beach ridges, which were never calibrated.

Table 1: Radiocarbon dates from Lake George (taken from Singh and Geissler 1985).

DEPTH (cm)	LAB NUMBER	ORGANIC AGE BP	ERROR +/-	CARBONATE AGE BP	ERROR
20-30	N-1845	975	100		
20-30	**ANU-1637**	**3430**	80		
40-43	**ANU-1638**	**5460**	170		
85-89	**N-1512**			**7770**	110
140-150	**N-1814**	11300	510	**18600**	930
180-190	**N-1815**	28400	1700/1500	**25600**	445
225-235	**N-1816**	27100	1050/4250	**>37800**	
280-290	N-1817	35700	4250-2800		
292-300	N-1513	12400	460		
		31300	1170		
309-314	N-1514	31300	1170		
320-330	N-1818	30300	1700/1400		
340-350	N-1819	2300	1800/1500		
440-445	N-1515			>37800	
503-510	N-1516	22500	640		
546-653	N-1517	3700	1570		
701-706	N-1518	29600	2500		
854-860	N-1519			>37800	

Samples and dates in bold italics are those which Singh made available to De Dekker (De Dekker, 1982).
The dated horizons came from core LG2 and subsequently correlated to layers in core LG4. Only those dates appeared in Singh et al (1981b).

Table 2: AMS dating for Lake George sediments and ostracods from core LG2

OSTRACODS (MANY SPECIMENS OF THE FRAGILE BUT WELL PRESERVED LIMNCYTHERE DORSOSICULA)								
DEPTH (cm)	SAMPLE NUMBER	WEIGHT (MG)	$\delta^{13}C$	PMC	PMC 1δ ERROR	CONVENTIONAL ^{14}C AGE	1δ ERROR	ANSTO REFERENCE
198	LG P11	0.56	-0.64	0.47	0.24	43100	4100	OZB047U
126	LG P14	0.21	2.30	4.69	1.13	24600	1950	OZB529U
285	LG P16	0.26	2.21	7.46	0.74	20800	800	OZB524U
335	LG P18	0.31	0.76	2.2	0.57	30700	2100	OZB527U
495	LG P27	0.22	-0.14	4.54	1.36	24800	2450	OZB049U
ORGANIC EXTRACTS								
198	LG P11	032	-16.6	66.26	0.38	3310	50	OZB325U
210	LG P12	0.19	-24.05	49.38	0.98	5670	160	OZB323U
260	LG P14	0.03	-22.5	63.59	21.71	3640	2750	OZB321U
285	LG P16	0.72	-22.5	68.61	4.17	3030	490	OZB324U
335	LG P18	0.86	-21.21	48.76	0.78	5770	130	OZB326U
495	LG P27	0.66	-17.63	73.75	0.43	2450	50	OZB320U

Sample preparation by Alison Barrie, graphitized by John Head, ANU, and analysed at ANSTO by Euan Lawson.

Nevertheless, it is apparent that Lake George did yield freshwater during part of the LGM (upon assessing the uncertainties of the beach ridges and ostracod chronologies).

Finally, one important observation can be made based on the assemblages of ostracods recovered from the Lake George core. On a number of occasions, three species of ostracods were found together in several samples. These are *Ilyocypris australiensis, Ilyodromus viridulus* and *Limnocythere dorsosicula*. Today, these three species are never found together in lakes, but each species is found in alkaline waterbodies. It is postulated therefore that alkalinity levels of Lake George must have been much higher than today when the combination of the three ostracod species occurred. This is no surprise as CO_2 levels in the atmosphere were definitely lower as identified in the ice cores. The dating of these events (see figure 8 in De Deckker, 1981) are not clear for the reasons explained above, but it appears that the samples were deposited during the LGM *sensu lato*.

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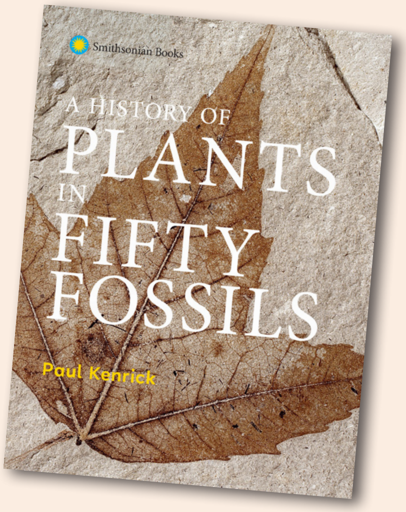
ADDITIONAL COMMENT

As elegantly said by the historian Dr Ann Jackson-Nakano (2001), Lake George was renamed in 1820 by Governor Lachlan Macquarie from what was referred to previously as Wee-ree-waa by the indigenous people. The first European to visit the lake was ex-convict explorer Joseph Wild (on August 19, 1820). Wild listed this name in a letter sent to Charles Throsby who eventually informed Governor Macquarie, just a few days later, of the discovery of this “brackish water lake and unfit for use”.

This year, being the 200th anniversary of Governor Macquarie visiting the lake (writing in his dairy on October 28, 1820) that he was re-naming it “in honour of present Majesty George IV”, it is opportune that we return to the original name of the lake which likely was visited by numerous generations of early Australians well before Governor Macquarie. The current preferred spelling of Weereewa is signposted at Geary’s Gap where, on the western side of the lake, is the point of the last overflow during the Late Pleistocene. Current discussions with Ngunawal people will soon confirm the original name of the lake. There is a possibility that Weereewa may have to be changed.

BOOK REVIEW



A History of Plants in 50 Fossils

Paul Kenrick

CSIRO Publishing & Natural History Museum, London. 160 pp

https://www.publish.csiro.au/book/7973/#details

ISBN 9781588346711

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The vast concepts covered in this book, on the origin and evolution of plant life on Earth and how plants have dramatically changed global environments, are a reminder of the tremendous depths of geological time recorded in Earth's rock layers. Dr Paul Kenrick has accomplished a feat to impart this incredible story using a mere 50 fossil samples. When did plants move out of the oceans onto land? What drew them into this challenging environment? How did plants cope with the associated issues (such as respiration, desiccation, support, nutrition and reproduction) to evolve over millions of years into the flowering plants we see dominating the world's flora today? These are big questions in land plant evolution told in this fascinating and beautifully presented book.

Dr Paul Kenrick is a pre-eminent scholar in palaeobotany and an authority on early land plant evolution, working first at Swedish Museum of Natural History, then for the majority of his career, since 1998, at the Natural History Museum, London, U.K.. The most celebrated early land plant, *Cooksonia*, whose namesake was Dr Isabel Cookson from The University of Melbourne, captured Dr Kenrick's interest as a student that led him into a career in palaeobotany. His research merges two disciplines of science: botany and geology; by using fossils to delve into the evolutionary history of land plants, in both space and time, Dr Kenrick has fundamentally changed our understanding of the earliest life cycles, ecosystems and how different plant parts evolved (e.g. Kenrick, 2017). His voluminous body of publications has predominantly focused on Scotland's Devonian Rhynie Chert and other Devonian deposits in Wales, but also reflects his research on global plant evolution throughout the Geological Timescale. A significant challenge to palaeobotanists is the disaggregation of plants into many parts in the fossil record, that often leave little clue as to their parent plant. Playing the part of sleuth and code breaker, Dr Kenrick has hunted fossils, painstakingly pieced together the puzzle to reconstruct whole plants, and has used modern DNA, validated by fossils, to elucidate plant lineages. Prior book authorship includes a specialist tome on the origin and evolution of early land plants using cladistics, co-authored with distinguished palaeobotanist, Professor Peter Crane (Kenrick and Crane, 1997).

Only relatively few privileged people, such as palaeobotanists, are permitted to go behind the scenes of the world's most revered natural history museum. Dr Kenrick led us on a meandering trail, past Dippy in the Hintz Hall, down Fossil Way, where Mary Anning's marine reptile collections are on display, to a secret door that opened into a whole new world. Treasures entombed within rows of antique drawers, often locked away for centuries and never to see the light of day, have been liberated and shared with the world through this book. Indeed, a stroll through the Natural History Museum, London enticed Sir David Attenborough to present his BBC TV documentary "Natural History Museum Alive" (Attenborough, 2014), and is endorsed by millions of people who visit the Museum each year.

Breathtaking images tell stories in themselves and capture the beauty and uniqueness of the 50 samples, mostly catalogued within the Natural History Museum (London) (NHM), that gives this book wide appeal. Exquisite photographs aid the reader in learning about the different times and major events through Earth history. Starting with bacteria and the origin of life, the book traces the evolution of all major lineages, ferns, conifers and finally, flowering plants. The format is easy to dip in and out of, from billions of years, to millennia, to the recent era, where each sample is captured frozen in time. Images of fossils, peppered by collection sites, are juxtaposed against the text on the opposite page, written in a way that is accessible to professional and general audiences alike. Dr Kenrick's choice of samples, together with his eloquent writing, reflect his breadth and depth of knowledge on the various aspects of land plant adaptation and evolution. From the title, which announces a finite limit to the plant fossils by its numerical notation, the book may appear at the surface as a simplistic catalogue. However, this extraordinary book is able to divulge incredible secrets from the specimens, to deliver a narrative on the antiquity of floral evolution, thus; a catalogue is the book's strength, through which Dr Kenrick simplifies systematics in a similar way to Banks' Florilegium (Solander et al., 1980).

Chapters are called themes; ingenious side headers are used for each chapter to avoid interruption of the flow through the book as it unfolds, revealing each of the 50 fossils. These themes give extra structure to the book in addition to time and are divided on the significance of the fossil in Earth's history. In this book, different plant parts, often fossilised by various means, are used to depict discrete portions of how plant structures evolved and adapted to different environments: roots, stems, woody trunks, leaves, leaf cuticles with stomates and epidermal cells, microscopic pollen, seeds, fruits and flowers are all on display. Unusually, the appendices are a defining part of the book and equally as important as the themes, as they hold the vital information where one can burrow down to find out why these particular 50 samples were chosen, where in the world they come from and whether they are held in the NHM.

My favourite theme within the book is "Climate and Diversity", where the reader can journey via the fossil 'time-machine' back to past worlds; where continents have shifted and vast forests grew in Antarctica and right across Gondwana for millions of years. These forests were dominated by dinosaur trees, the Wollemi Pines and Monkey Puzzles, conifer relatives in the family Araucariaceae. A single, poignant moment is crystallised in time by a photograph of Antarctica's last remaining leaves fallen from the deciduous Southern Beech tree, *Nothofagus*.

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THESIS ABSTRACTS

CLIMATE, HUMANS, FIRE AND MEGAFAUNA – KEY DRIVERS OF AUSTRALIAN SUBTROPICAL VEGETATION CHANGE

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The timing and cause of megafauna extinctions across Australian, and indeed around the world, have been strongly debated particularly since Martin (1967) first implicated human agency as a major factor in megafauna disappearances. The cause of the demise of the megafauna has been the focus of many studies, yet no work to date has developed independent environmental and climate reconstructions from a single Australian location in relation to megafauna extinctions. Sedimentary records from wetlands provide a particularly powerful archive to examine terrestrial ecosystem change in response to internal and external drivers across a variety of spatial and temporal scales. The presence of coprophilous fungi spores, such as *Sporormiella*, preserved in wetland sediments can indicate the local presence of large herbivorous, including extinct megafauna. Records of megafauna presence can then be coupled with palaeoecological and palaeoclimatological proxies to disentangle the influence of climate on terrestrial ecosystem change and the timing of megafauna disappearance. Sedimentary records that extend beyond the Holocene in Australia are rare. Rarer still are long, continuous, high-resolution records that extend beyond Marine Isotope Stage 3 (MIS3; 57 – 29 ka), a period of substantial significance in Australia that encompasses human arrival and megafauna extinctions.

In this thesis I integrate a range of proxies from an 80,000 year old, well-dated, continuous sedimentary sequence from Welsby Lagoon, North Stradbroke Island to investigate the climate and environmental variability of subtropical eastern Australia from MIS4 to present. In this thesis I present, for the first time at a single location, records of inferred megafauna presence, local fire occurrence, vegetation change and independent local climate variability. Understanding the development of the wetland system and identification of changes in depositional environment at ca. 28 ka provides a robust basis for interpretation of proxies.

During MIS4 and the Holocene fire is an important component of the surrounding landscape and drives vegetation change, with a more limited influence during MIS3 and MIS2. The largest changes in the vegetation around Welsby Lagoon occur between 55 – 40 ka, in the absence of frequent fire and coincident with the timing of widespread human migration and megafauna extinction. The shifts in vegetation during this period are predominantly driven by changes in climate, as inferred from the $\delta^{13}C$ of bulk sediment and the $\delta^{18}O$ of aquatic cellulose. The climate of this period displays a high level of variability as well as a shift to drier climates at ca. 54 and again at 43 ka. In addition to driving changes in vegetation dynamics, *Sporormiella* disappeared from the record at this time, during the shift to drier climate conditions.

Within chronological uncertainty, the changes in vegetation composition and hydroclimate at ca. 43 ka at Welsby Lagoon are concurrent with abrupt changes in the Darling River region and central Australia as well as five vegetation records from across the central and eastern Australia. The data suggest that climatic change was major contributor to megafauna and vegetation change during Marine Isotope Stage 3.

Martin, P.S., (1967). Prehistoric overkill. *Pleistocene Extinctions: The search for the cause*. Martin P.S. & Wright, H.E. (Eds.). Yale Uni. Press, New Haven, USA. pp354 - 403.

HIGH-RESOLUTION COMPOSITE STRATIGRAPHY AND MULTI-METHOD DATING OF AUCKLAND MAAR SEDIMENT RECORDS SPANNING THE LAST GLACIAL INTERVAL

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Palaeoclimatic reconstructions are key to understanding and quantifying nature, rates, and drivers of palaeoclimatic changes and fundamental to predictions of future climate change. A holistic picture of past changes and their drivers requires wide spatial and temporal coverage of palaeo-climate archives but few suitable mid-latitude terrestrial records from the SW Pacific exist. In this context, the Orakei maar sediment sequence (Auckland, New Zealand) provides a continuous and high-resolution archive of palaeoclimatic and – environmental changes in the region. Nevertheless, without a robust composite stratigraphy and chronology, multi-proxy changes recorded in the sediment sequence cannot be interpreted in a regional, let alone global, palaeo-climate context.

This thesis aims to develop a composite stratigraphy, robust chronology and detailed chemo-stratigraphy with which to assess palaeo-environmental change from Orakei maar.

As part of this study, the Orakei eruption age has been constrained to >139 200 ± 820 yr and thereby constrains the sedimentation onset in Orakei maar to marine isotope stage (MIS) 6. The sequence contains a continuous lake sediment archive until ca. 9750 cal. yrBP when post-glacial sea-level rise breached the crater rim. For the first time, this study demonstrated that µ-XRF core scanning allows rapid tephra identification in sediment cores. However, an extensive reference µ-XRF database is necessary for future applications using this approach to identify tephra in sediment cores.

Tephrochronology, radiocarbon dating and correlation of relative palaeointensity variations of the Earth's magnetic field were successful for chronology development whereas luminescence dating and 10Be radionuclide variations could not improve the Orakei chronology due to rapid influx of detrital sediment. The chronology allows the placement of the Orakei palaeoclimatic change in a robust temporal framework. Based on µ-XRF elemental variability, no MIS 5 sub-stages could be differentiated, MIS 4 is an environmentally homogeneous, cool interval, whereas MIS 3 displayed considerable geochemical variability signifying increased climatic instability.

This study produced the first long, high-resolution and complete lake sediment record from the Southern Hemisphere mid-latitudes anchored in a robust chronology extending beyond the radiocarbon dating limit and offers unique possibilities for detailed palaeoclimatic reconstructions based on the µ-XRF-inferred evolution of Orakei maar.

ASSESSING THE DENDROCLIMATIC POTENTIAL OF THE GREY MANGROVE (*Avicennia marina*) IN NEW SOUTH WALES, AUSTRALIA

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Assessing the risk of future extreme drought and flood events in Australia is a challenging exercise, due to the relatively short length of observational climate records. However, palaeoclimate proxy data extracted from tree rings may be used to reconstruct pre-instrumental climate, thus extending the temporal and spatial coverage of Australian climate data. The number of climate sensitive physicochemical and anatomic parameters that may be extracted from wood is ever increasing, and radiocarbon dating may provide the necessary temporal control in lieu of cross-datable annual growth rings. Approaches utilising radiocarbon have reduced the dependence on annual growth rings, unlocking the potential for tree species to be used for palaeoclimate research that were previously assessed as being unsuitable. Increasing interest in mangroves for dendroclimatology research has led to the discovery that xylem vessel size and abundance and the stable isotopes of carbon and oxygen vary through time in some species in response to climate. However, the most common mangrove across much of Australia – the grey mangrove (*Avicennia marina*), grows radially via successive cambia; a complex mode of secondary growth that is still not well understood. Nevertheless, radiocarbon dated profiles of wood density measurements have been found to correlate significantly with the Pacific Decadal Oscillation, a major driver of rainfall variability across Australia. To date, time-series of the most promising climate sensitive parameters found in other mangrove species (xylem vessel anatomy, carbon and oxygen isotopes) have not been investigated in relation to climate in the grey mangrove. There are also some unresolved questions regarding the periodicity of grey mangrove successive cambia layers, with significant implications for dendroclimatic investigations in the species.

The present study sought to address this research gap using grey mangrove stem sections obtained from the Port Stephens and Hunter River estuaries in NSW. Time-series of stable isotope ratios and xylem vessel measurements from these stems were prepared using bomb-pulse radiocarbon dating and then correlated with a range of local and large-scale climate indices. Significant spearman correlations were found between carbon and oxygen isotope ratios ($\delta^{13}C$, $\delta^{18}O$), rainfall, sea level and multiple El-Nino Southern Oscillation (ENSO) indices (ranging from $r = -0.27$ to $r = -0.46$). Xylem vessel density was associated only with autumn rainfall, but the month of autumn featured consistently amongst the stable isotope correlations with both rainfall and ENSO. This consistency provides additional support for the hypothesised climate influence on grey mangrove wood chemistry and anatomy, and these findings underscore the potential for grey mangroves to be used to reconstruct pre-instrumental climate in Australia. There is unpublished evidence that grey mangroves may grow to over a thousand years of age and they are extremely common on parts of the Australian coastline where palaeoclimate proxy data are currently unavailable. Importantly, if mangroves growing on the Australian coast contain a record of drought and pluvial events over much of the past millennium, they could prove a critical resource for deepening our understanding of past climate variability in Australia. A comprehensive understanding of the spatial and temporal variability of past Australian hydroclimate is needed to improve accuracy in the assessment of future hydrologic risk under a variable and changing climate.

UPCOMING MEETINGS

Editors COVID19 note: While every effort has been made to confirm that these meetings are still 'going ahead' as planned (or that details have changed) please double check with individual meetings organising committees, or on their webpages, for the latest information and possible virtual conference options.

SEPTEMBER 2020

37th General Assembly of the ESC

Venue: Corfu, Greece
Date: 6-11 September, 2020
www.inqua.org/meetings/list/42

3rd International Conference on Polar Climate and Environmental Change in the Last Millennium

Venue: Toruń, Poland
Date: 24-26 September, 2020

OCTOBER 2020

Ponto-Caspian Stratigraphy and Geochronology (POCAS)

Venue: Tehran, Iran
Date: 11-18 October, 2020
www.inqua.org/meetings/list/40

41st Nice Côte d'Azur International Meeting of Archaeology and History

Venue: Université Côte d'Azur (France)
Date: 12-15 October, 2020
www.inqua.org/meetings/list/52

NOVEMBER 2020

PAGES-INQUA joint ECR workshop: Past Socio-Environmental Systems (PASES)

Venue: La Serena y Coquimbo, Chile
Date: 9-13 November, 2020
www.pases2020.com
online sessions held in November 2020 and in-person meeting rescheduled for 2021.
Questions: workshop.pages.ecn@gmail.com or on Twitter (@pases2020)

PATA Days 2020

Venue: Hornitios, Chile
Date: 8-12 November, 2020
www.inqua.org/meetings/list/34

3rd International Conference on Polar Climate and Environmental Change in the Last Millennium

Venue: Toruń, Poland
Date: 23-25 November, 2020
The 3rd International Conference on Polar Climate and Environmental Change in the Last Millennium has been rescheduled to be held from 23-25 November 2020 in Toruń, Poland. It was originally planned for 24-26 September 2020.
http://pastglobalchanges.org/calendar/2020/127-pages/1985-polarclimate2020

2021

JANUARY 2021

Australian Earth Sciences Convention (AESC)

Venue: Hobart Tasmania.
Date: 9-12 Feb 2021
www.aesconvention.com.au

MARCH 2021

IAL IPA joint meeting "Lagos, Memorias del Territorio"

Venue: BEC Bariloche Events and Congresses, (Argentina)
Date: 21-25 March, 2021
www.inqua.org/meetings/list/55

MAY 2021

XV International Palynological Congress XI International Organisation for Palaleobotony Conference

Venue: Prague, Czech Republic
Date: 1-7 May, 2021
www.prague2020.cz
Rescheduled from September 2020
Submissions open until September 2020.

JUNE 2021

European conference on earthquake engineering and seismology

Venue: International Conference Centre, (Romania)
Date: 19-24 June, 2021

JULY 2021

AQUA Conference, 2020

Venue: Atherton Tablelands, Far North Queensland.
Date: rescheduled July, 2021
https://aqua.org.au/conference/

SEPTEMBER 2021

6th Regional Scientific Meeting on Quaternary Geology: Seas, Lakes and Rivers

Venue: Atrium ZRC SAZU, (Slovenia)
Date: rescheduled 27-30 Sept, 2021
https://www.inqua.org/meetings/list/54
https://www.geo-zs.si/rmqg/#

The 15th International Conference on Accelerator Mass Spectrometry (AMS-15)

Venue: University of New South Wales (UNSW), Sydney, Australia.
Date: rescheduled Sept 2021
https://ams15.sydney

OCTOBER 2021

3rd IPICS Open Science Conference, "Ice Core Science at the three Poles"

Venue: Crans-Montana, Switzerland
Date: rescheduled October 2021
https://indico.psi.ch/event/6697/

NOVEMBER 2021

PAGES-INQUA joint ECR workshop: Past Socio-Environmental Systems (PASES)

Venue: La Serena y Coquimbo, Chile
Date: rescheduled Nov, 2021
www.pases2020.com

ADVANCE NOTICE

19th International Swiss Climate Summer School, Extreme weather and climate: from atmospheric processes to impacts on ecosystems and society

Venue: Grindelwald, Switzerland
Date: rescheduled August, 2022
New call open in September 2021
http://pastglobalchanges.org/calendar/2020/127-pages/1982-swiss-summer-school-2020

2022 ICAZ International Conference in Cairns, Australia

Venue: Cairns, Australia
Date: 8-13 August, 2022

To facilitate ongoing planning for ICAZ2022, the conference organising committee would like to establish an initial level of participation at the conference. It would be greatly appreciated if the attendance questionnaire (comprised of six questions) could be completed, providing us with a preliminary indication of delegate numbers. The questionnaire can be found at: https://forms.gle/jevzdezsH89JAiu8

XXI INQUA congress

Venue: Rome, Italy
Date: 13-20 July, 2023
https://www.inqua.org/meetings/list/37

RECENT PUBLICATIONS

Abbott, P.M., Jensen, B.J.L., Lowe, D.J., Suzuki, T., Veres, D., (editors) (2020). Tephrochronology as a global geoscientific research tool. *Journal of Quaternary Science*, 35 (1/2):1-379. https://onlinelibrary.wiley.com/toc/10991417/2020/35/1-2 [free open access until Jan 2021]

Abbott, P.M., Jensen, B.J.L., Lowe, D.J., Suzuki, T., Veres, D., (2020). Crossing new frontiers: extending tephrochronology as a global geoscientific research tool. *Journal of Quaternary Science*, 35 (1/2):1-8. https://doi.org/10.1002/jqs.3184

Allen, K.J., Hope, P., Lam, D., Brown, J.R., Wasson, R.J., (2020). Improving Australia's flood record for planning purposes – can we do better? *Australasian Journal of Water Resources*. https://doi.org/10.1080/13241583.2020.1745735

Bourman, R.P., Buckman, S., Chivas, A.R., Ollier, C. D., Price, D.M., (2020). Ferricretes at Burringurrah (Mount Augustus), Western Australia: Proof of lateral derivation. *Geomorphology*, 354. https://doi.org/10.1016/j.geomorph.2019.107017

Bourman, R.P., Banerjee, D., Murray-Wallace, C-V., Buckman, S., Panda, D.K., Belperio , A.P., Jayawardena, C.L., (2020): Luminescence dating of Quaternary alluvial successions, Sellicks Creek, South Mount Lofty Ranges, southern Australia, *Australian Journal of Earth Sciences*. https://doi.org/10.1080/08120099.2020.1722967.

Hartemink, A.E., Zhang, Y., Bockheim, J.G., Curi, N., Silva, S.H.G., Grauer-Gray, J., Lowe, D.J., Krasilnikov, P., (2020). Soil horizon variation: a review. *Advances in Agronomy*, 160:125-185. https://doi.org/10.1016/bs.agron.2019.10.003.

Kelly, J.T., McSweeney, S., Shulmeister, J., Gontz, A.M., (2019). Bimodal climate control of shoreline change influenced by Interdecadal Pacific Oscillation variability along the Cooloola Sand Mass, Queensland, Australia. *Marine Geology*, 415. https://doi.org/10.1016/j.margeo.2019.105971

Kluger, M.O., Jorat, M.E., Moon, V.G., Kreiter, S., de Lange, W.P., Mörz, T., Robertson, T., Lowe, D.J., (2020). Rainfall threshold for initiating effective stress decrease and failure in weathered tephra slopes. *Landslides*, 17:267–281. https://doi.org/10.1007/s10346-019-01289-2

Paspaningrum, M.R., van den Bergh, G.D., Chivas, A.R., Setiabudi, E., Kurniawan, I., (2020). Isotopic reconstruction of Proboscidean habitats and diets on Java since the Early Pleistocene: Implications for adaptation and extinction. *Quaternary Science Reviews*, 228: https://doi.org/10.1016/j.quascirev.2019.106007

Shaw, B, Field, J.H., Summerhayes, G.R.S., Coxe, S., Ford A., Arifieae, H., Coster, A.C.F., Jacobsen, G., Fullagar, R., Hayes, E., Kealhofer, L., (2020). Emergence of a Neolithic in Highland New Guinea by 5000-4000 years ago. *Science Advances*, Vol. 6, no. 13. https://doi.org/10.1126/sciadv.aay4573

Top: East side panorama. View over old growth forest and Little Ice Age moraine toward the upper part of the fjord. Note the trimline in the distance. (All Photos: Tim Barrows)

Middle: East side. Little Ice Age moraines and drowned trees from damming.

Right: Coring an old growth tree

Above: Carnivorous plants Drosera and Pinguicula

See article Page 8

Quaternary AUSTRALASIA

Quaternary Australasia publishes news, commentary, notices of upcoming events, travel, conference and research reports, post-graduate thesis abstracts and peer-reviewed research papers of interest to the Australasian Quaternary research community. Cartoons, sardonic memoirs and images of mystery fossils are also welcome.

The Australasian Quaternary Association (AQUA) is an informal group of people interested in the manifold phenomena of the Quaternary Period. It seeks to encourage research by younger workers in particular; to promote scientific communication between Australia, New Zealand and Oceania; and to inform members of current research and publications. It holds biennial meetings and publishes the journal Quaternary Australasia twice a year.

Full annual membership of AQUA with an electronic subscription to QA is AUD50. For students, unemployed or retired people, the membership is AUD25 (for hard copy QA) or AUD20 (for electronic QA). The AQUA website (www.aqua.org.au) has information about becoming a member; alternatively please contact the Treasurer. Members joining after September gain membership for the following year. Existing members will be sent a reminder in December.