VOLUME 38 | NUMBER 2 | DECEMBER 2021

Quaternary AUSTRALASIA

Pioneering Female Quaternarists

AQUA Conference reports

Searching for Palaeo Archives in the Kimberley

AQUA Current life members

Current life members are Jim Bowler, Eric Colhoun, John Chappell (dec), Peter Kershaw, John Magee and Matt McGlone. With new life member Geoff Hope.

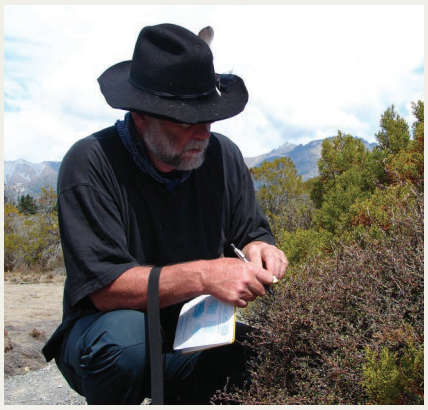
Jim Bowler
(Photo credit: socialpolicyconnections.com.au)

Eric Colhoun
(Photo credit: Tim Barrows)

John Chappell (dec)
(Photo credit: Helen Chappell)

Peter Kershaw
(Photo credit: ANU)

John Magee
(Photo credit: Giff Miller)



Matt McGlone
(Photo credit: Manaaki Whenua Landcare Research)

NEW LIFE MEMBER

Geoff Hope
(Photo credit: https://iceds.anu.edu.au/people/academics/professor-geoffrey-hope)

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ISSN 0811-0433

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Front cover photo:

Hot and dusty coring at Birrindudu station. (Photo credit: Rachel Rudd)

Below:

View of the Varve Museum, Fukui prefecture, Japan. See "News from the Field". (Photo credit: Henk Heijnis)

EDITORIAL

Dear Quaternarists,

Carol Smith and I have decided to hand over the editing 'reins' to new QA Editors: Emma Rehn and Lydia Mackenzie. Since our first edition in July 2016, it has been great to have worked with all the contributors from the AQUA community. We thank you all for your support and patience with our hounding for content and editing approvals. Please continue your wonderful support for QA by contributing your news, comments, and research content to Emma and Lydia.

One of the highlights of this issue is the compilation of biographies and stories on trailblazing female Quaternarists, gathered and edited by Helen Bostock. Among the contributors are Ali Kimborough, Chris Turney, Janelle Stevenson, Gill Atkin, Helen McGregor, Justine Kemp, Kathryn Taffs, Linda Ayliffe, and Linda Nothdurft, among others.

This collection provides a glimpse of the wide-ranging contributions made by female Quaternarists in a wide range of Quaternary disciplines. We look forward to, and encourage, further contributions of biographies and tributes to women in Quaternary Science for future issues of QA.

Also in this issue are:

Reflections of a career in Quaternary science by Henk Heinjis,

A field work report from the Kimberleys by Teresa Dixon, Rachel Rudd, Hamish McGowan and Nik Callow,

Reports about our online AQUA Conference (2021) by Lucinda Duxbury and Nicolas Patton,

An article on a new version of a database for pollen and spores by Simon Haberle and his team,

A rebuttal to an article published in the last edition of QA (Vol 38 July 2021 by De Deckker and Murray-Wallace) by Tom Hubble, and his colleagues.

As you can see there is lots of great reading in this edition.

Go well all, stay safe and have a wonderful holiday break, however you choose to celebrate it.

Sanja van Huet and Carol Smith,
(retiring) Co-editors

Yours Quaternarily,

Emma Rehn
Co-editor

Lydia Mackenzie
Shadow Co-editor

PRESIDENT'S PEN

Kia ora koutou; greetings fellow AQUA members,

Thank you to everyone who presented at the AQUA pop-up conference in July. It was really great to see such exciting and innovative research being conducted, particularly by students and ECRs. There were many outstanding presentations, which made it a very difficult decision for the judging panel when it came to prizes. Congratulations to Jenni Hopkins, Emma Rehn, Nick Patton and Lucinda Duxbury who have each been selected for a carbon-14 internship award, funded by the Centre of Excellence for Australian Biodiversity and Heritage (CABAH), through the CHRONOS ^{14}Carbon-Cycle Facility at the University of New South Wales. Congratulations also to Olivia Traux and Danielle Udy who received an AQUA award for best conference presentation. The judging panel also recognised highly commended presentations from Vikki Lowe, Rebecca Ryan, Sarah Cooley and Sophie Williams. Thanks very much to those involved with the conference organisation and chairing of sessions!

The AGM was a great success, with an excellent discussion around equity and inclusivity in AQUA. Thank you very much to those who contributed. Please see Haidee Cadd and Lynda Petherick's report on the data collected from the pop-up conference later in this issue.

Following the AGM, there were a few changes made to the AQUA executive committee. Carol Smith stepped down as QA co-editor after many years of service. Thanks very much Carol for all your work! The following new people have joined the exec:

- Emma Rehn (QA Co-editor)
- Lydia Mackenzie (Shadow QA Editor)
- Annie Lau (Inclusivity and Equity focus – new position)
- Caroline Mather (ECR focus – new position)
- Micheline Campbell (Shadow IT)
- Nick Patton (NZ representative)

I would also like to acknowledge the contributions of Michelle McKeown, who is leaving the committee due to taking a new position in her native Ireland. Thanks for all your work, Mich!

At our most recent exec meeting we had a discussion around instigating an AQUA mentoring programme. Watch the AQUA-list for more information.

The dates for the 2022 AQUA conference (hopefully in person!) have been tentatively decided for 6 – 8 December, at the University of Adelaide. More details to come, but already it is looking like it is going to be another excellent meeting, with discussions around equity and ECR support already pencilled in.

Congratulations to Emeritus Professor Geoff Hope, who has been awarded AQUA Life Membership. Geoff has made outstanding contributions to our community. His work has significantly advanced our understanding of the Quaternary in Australasia. Further, Geoff was a fundamental member in the early days of AQUA, and has served in several leadership roles. Thank you very much Geoff for your incredible research and career.

Finally, thank you to Helen Bostock (and everyone who has been involved) for initiating this issue of QA recognising female Quaternarists in our community.

Ngā manaakitanga; with best wishes,

Lynda Petherick
AQUA President

NEWS

Mentoring program

Following some valuable discussion at AQUA Online this year, which has continued amongst the AQUA Executive, we are hoping to launch a mentoring program later this year. There are several motivations behind this move: to continue the inroads that have already been made at increasing the level of collegiality in the Quaternary community; to support upcoming scholars; and to support MCRs as they progress into senior positions. We hope that these moves will also help to increase equity and diversity of all kinds and at all levels within the community.

Mentoring programs can provide an important source of support and guidance for PhD students, ECRs and MCRs alike, and facilitate building personal and professional relationships that are often highly valued by both the mentor and the mentee. We hope that many AQUA members from all stages of their career will take part as a mentee and/or mentor, with the aim to launch a year-long mentoring program in early 2022.

Keep your eyes open for more information later in the year.

Many thanks, the AQUA Exec

The new AQUA ECR blog

We have started an interview series on the AQUA ECR Blog (https://aqua.org.au/blogs/ecr-blog/) to ask AQUA researchers questions about their exciting research, science/academic journey, role models, life outside work, etc. If you want to be an interviewer or be interviewed, please get in touch with Annie (annie.lau@uq.edu.au). Read on for short excerpts from the first two interviews; head to the blog to read the full interviews.

INTERVIEW 1: DR HAIDEE CADD

"I originally went to university fully intending to become a zoologist working with Orang Utan's in the Borneo rainforests... I never knew that staring down a microscope at pollen grains was my passion, but I'm glad I got the opportunity to find out."

"I've spent quite a lot of time in the lab recently, maintaining and running the new MICADAS (Mini Carbon Dating Accelerator mass spectrometer) at the Chronos ^{14}C-Carbon laboratory at UNSW. This has been quite a steep learning curve, getting to know a completely new set of skills in both radiocarbon dating and engineering/ion beam physics. Working with the MICADAS in a custom-built radiocarbon laboratory has given me a whole new appreciation for the intricacy of radiocarbon dating and chronology building."

INTERVIEW 2: DR MICHELLE MCKEOWN

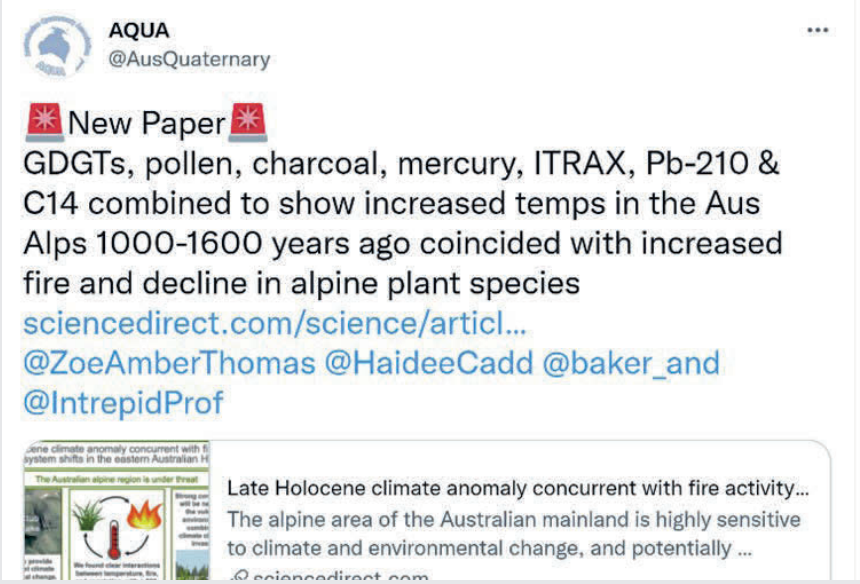
"I get to study sub-fossils and look for clues hidden in the earth to understand the past. It's just an incredible research area to be in."

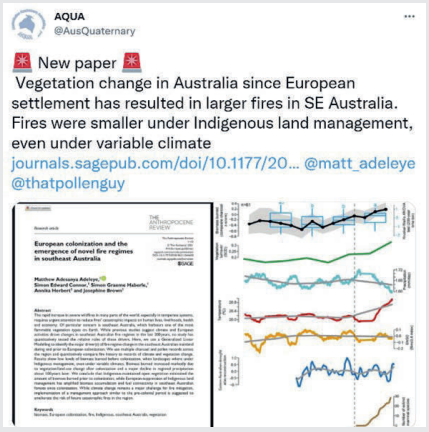
"I would suggest getting as many broad practical skills as you can while in academia. I found that my statistical skills and ability to code in R has been incredibly sought after. For anyone working at a university, helping in labs and field exercises in subjects outside your research area is a great way to develop a broader skillset."

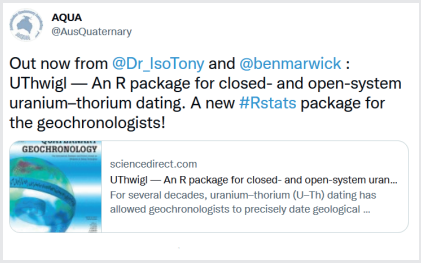
Do you have a paper coming out?

WANT TO ADVERTISE A NEW JOB OR SCHOLARSHIP OPPORTUNITY?

Reach a wider audience with the help of the @AusQuaternary Twitter account! If you would like @AusQuaternary to promote your work either send a Twitter message or email us at communications@aqua.org.au. With over 500 followers all over the world (and more joining every week), we can help your work reach a broad audience, even if you are not on Twitter!







MEET A MEMBER OF THE AQUA EXECUTIVE COMMITTEE

ANNIE LAU

I am a lecturer at the University of Queensland. My research focuses on coastal geomorphology, including the long-term evolution of shorelines, and how extreme events like storms and tsunamis would change the landscape and leave traces in the stratigraphy in a matter of minutes to days. Most of my research involves reconstructing the history of storms and tsunamis, and to interpret the characteristics of individual extreme coastal hazard event using sedimentary evidence including sand layers and large coastal boulders. I am an active member in the international coastal geohazard community as I am currently an ECR representative at INQUA (Coastal and Marine Processes Commission), a project leader of the new IGCP 725 "Forecasting coastal change" project, and a steering committee member of a research coordination network that brings together researchers that investigate wave-deposited coastal boulders. Please let me know if anyone wants to get involved in these communities.

Before coming to Brisbane, I did my undergraduate and MPhil studies in Hong Kong, then I moved to Singapore to complete a PhD. Apart from science, I love travelling and eating. I'm a big foodie and some friends recently commented that I adapt to new places very well as I can learn my way through a city quickly by having a "map of eateries" in my mind. I think I have just discovered my natural talent!

Figure 1: Post-cyclone survey on the reefs of Taveuni Island, Fiji. (Photo: James Terry)

A STORY IN TWO PARTS: TWO VISITS TO THE "HOLY GRAIL" OF QUATERNARY SCIENCE & SOME REFLECTIONS ON A CAREER IN QUATERNARY SCIENCE

Henk Heijnis

Past President and retired Quaternary Scientist

It was during the XIX INQUA Conference in Nagoya that the first opportunity to visit the Lake Suigetsu area presented itself. Keen to go on one of the mid-conference tours, the decision was easy as the guardian of the unique site with laminated sediments, Professor Takeshi Nakagawa, was leading the tour. We took off early morning in a north-westerly direction towards Lake Biwa. Having driven around the eastern shore for a while we reached the area with the five lakes of which Suigetsu is the one with the preserved varves. A few things were particularly memorable that day, firstly the site where they re-sampled the lake sediments in the early 2000s and in particular the small shed where Takeshi stored and prepared the core lengths for further analysis in the laboratory. After this we visited a temporary and somewhat old building where we could see one of the core-lengths close up. This was a wonderful experience, and all 40 participants were keen to get a close look at the 1-meter length of sediment from Suigetsu. Probably a little difficult to get a really get look, but nevertheless very impressive. After this visit were off to the regional Wakasa-Mikata Museum of the Jomon period. The museum is situated on the banks of Mikata Lake, the sister lake of Suigetsu and a famous archaeological site of the Jomon period (14,000 – 300 BCE). A wonderful, mostly underground, museum with very good visuals of the transition from hunter gatherers to more sedentary agriculturalists. Their pottery and figurines are very distinct and copies make great souvenirs.

Fast forward to 2019: it is now the second year of the Forum for Nuclear Cooperation in Asia's (FNCA) project on climate change. The project, led by ANSTO, was set-up to get regional comparison studies (amongst the member countries – Australia, China, Mongolia, Kazakhstan, Japan, Thailand, Indonesia, Bangladesh, Vietnam, Philippines, and Malaysia) on both soil-carbon and paleoclimate records. Our colleagues from the Japanese Ministry of Education, Culture, Sports, Science and Technology invited us for the third project meeting. My request as leader was not to have it in Tokyo and incorporate a field visit to one of the sites for Paleoclimate studies. I was pleasantly surprised that we were offered a meeting in Kyoto and a few days in Tsuruga. Immediately I realised that Tsuruga is next to the Fukui prefecture, which is home to Lake Suigetsu. More importantly our Japanese counterparts had organised a day trip to the lakes area and invited Professor Takeshi Nakagawa to lead a tour of the newly opened Fukui Varve Museum. This was a wonderful surprise to me and an honour to our group. My surprise was even bigger when I realised that the Varve Museum had been build next to the earlier mentioned Wakasa-Mikata archaeology museum.

The museum is very elegantly designed to accommodate the main attraction, the Lake Suigetsu sediment core, to be displayed in one continuous section on a wall of about 50 metres long. It is an absolute thrill to walk from the present time back to about 76,000 varve years ago and stop every now and then to read up on the main features within the sediment record. The display core took a lot of time and money to be preserved in such a way that it could be displayed in the museum. A German expert in thin sections worked hard on cutting a very thin slice of each one metre core length and further preserving it between two glass plates. On the other side of the impressive wonder wall is a more general display and information on other varve lakes around the world, and an original copy of the book by Milankovitch himself on the theory of Ice Ages (which Takeshi himself picked up in a second-hand bookshop in Belgrade, Serbia). It was very heart-warming to see that such an important site and contribution to Quaternary Sciences was recognised by the local prefecture government and awarded such a prominent and purpose-build museum. http://varve-museum.pref.fukui.lg.jp/en

A career in Quaternary Science and to quote the Talking Heads from their song "Once in a Lifetime":

And you may find yourself in another part of the world
And you may find yourself behind the wheel of a large automobile
And you may find yourself in a beautiful house, with a beautiful wife
And you may ask yourself, "Well, how did I get here?"

But how did I get here and to see the wonder that is the Lake Suigetsu?

Well, if it hadn't been for the Geography curriculum in the Netherlands in 1978, I probably wouldn't have made it. The curriculum for Geography differed from year to year (some years the Human Geography component included USA and in others USSR). The Physical Geography component in 1978 included the Quaternary History of the Netherlands and I was hooked from day one and bought the handbook for the first-year students at the Vrije Universiteit, Amsterdam. About three years later, after my final exams and a stint in the army (compulsory) as a radio-operator/ graphic design assistant (which included a useful course in map reading and navigating), I found myself at the Vrije Universiteit, Amsterdam. At the time it was the only university in the Netherlands to offer a course in Quaternary Science and low land genesis at Master's level. During this seven-year stint at the Vrije Universiteit, I found myself to be a budding expert in sea-level studies, using pollen and macro-fossils as indicators. I combined radiometric dating (Pb-210) of recent sediments with pollen research to determine if tidal flats and saltmarshes were keeping up with both sea-level rise and subsidence of the North Sea basin.

My adventures in the Holocene came to an abrupt halt mid-1988, when I was offered a research council sponsored research assistant/ PhD scholarship at the University of Groningen, to use Uranium/ Thorium dating on interglacial and interstadial organic deposits in North-western Europe. In May 1988, I walked into the Physics building of the University of Groningen and started to humbly walk in the footsteps (or better – not to step on toes) of the icons and pioneers of radiocarbon dating. The Isotope Physics Laboratory (later Centre for Isotope Research) was founded by Professor Hessel de Vries (https://handwiki.org/wiki/Biography:Hessel_de_Vries); his life story is both impressive and almost something out of Inspector Morse, as it involves both murder and suicide. After his death in 1959, the group was led by Professor John Vogel, Professor Wim Mook and more recently (for radiocarbon) Professor Johannes van der Plicht.

The laboratory was also home to famous alumni with the likes of Professor Minze Stuiver, Professor Piet Grootes (both were instrumental setting up the radiocarbon laboratory at University of Washington and Piet later in Kiel, Germany) and Professor Pieter Tans (NOAA, greenhouse gas and radiocarbon).

Most of these icons were instrumental in the calibration of the radiocarbon timescale, all based on the early observation by de Vries and communication to Libby. See this article on Hessel de Vries in special issue of Radiocarbon (70 years of radiocarbon dating): https://www.cambridge.org/core/journals/radiocarbon/article/hessel-de-vries-radiocarbon-pioneer-from-groningen/BABA23217013E7A934671B5432040046

After 4 years of collecting and dating key Late Pleistocene sites, I published my thesis and got my doctorate. During those years I proved that the interstadial "radiocarbon" dated deposits of around 65,000 – 60,000 BP were in fact older and more in tune with the MIS stage 5 substages (125,000 – 100,000 BP). During this time my day-to-day supervisor Johannes van der Plicht was working with an international team on software for calibrating radiocarbon dates (now known as IntCal). This was also the period that van der Plicht started working with the original

Top Left – Figure 1: Visit to the Varve Museum to look at the display of varves. Lake Suigetsu has the world's longest varves (45m long and accumulated over 70,000 years!). Front middle is our guide and expert Professor Takeshi Nakagawa.

Left – Figure 2: The Varve Museum at Wakasa-cho, Fukui Prefecture (Source: http://varve-museum.pref.fukui.lg.jp/en).

Japanese team on using the absolute varve chronology from Lake Suigetsu for refinement and extension of the radiocarbon calibration curve. Kitagawa and van der Plicht published two important papers during the 1997 to 1998 period. My interest in those lake sediments was certainly awakened during the early 1990s.

At the start of my PhD project, I became interested and obsessed in long terrestrial records as they provided, at least, stratigraphic integrity (something individual organic layers of unknown age, wedged between un-dated glacial deposits, could not provide). My Palaeoecology supervisor in Amsterdam suggested I contact Professor Peter Kershaw. Professor Bruce Thom (visiting Amsterdam for a IGCP-270 sea-level meeting) suggested I contact Professor Eric Colhoun. A steady stream of boxes started arriving at my desk from Melbourne. Dr Merna McKenzie, as it later turned out, had spent countless hours sub-sampling lots of long records from the Atherton Tablelands. A sample every few centimetres in the most organic rich layers yielded a small mountain of material. Not everything worked out, as the new method could only reliably be applied to very few special cases. We also started collaborations with OSL researchers, who could date the overlying and underlying minerogenic sediment at some of the sites. These early studies showed that both methods could go hand in hand.

In August 1991 (my third year) the 7th International Conference on Geochronology, Cosmochronology and Isotope Geology (ICOG) was held at ANU, Canberra and this was my chance to present my work to an international audience. This first visit to ANU/Australia included a private trip to the Atherton Tablelands to see the unique craters for myself and a visit to Peter Kershaw at Monash directly after the conference. During the conference I met my future boss, Steve Short, who was working on U/Th dating at ANSTO. The following year, INQUA was held in Beijing, which in hindsight was a much better place for networking (read: drinking), especially with the Australians, who had landed in the same hotel as me (amongst them Peter Kershaw and Paul Hesse). Two years later, having just finished my PhD, Steve Short tipped me off on a job opening at ANSTO and so my trip around the world started. After arriving on St Patrick's day 1993 in Sydney, I'm still here.

The rest is history, but my ANSTO career had not been possible without the networking through AQUA of which I became a member within a few months after arriving. A highlight of my career was to be the president of AQUA during the INQUA conference in Cairns. In the beginning I was a lonely representative of ANSTO at both AQUA and INQUA meetings, but with the support of AINSE, ANSTO and AQUA this has now permanently changed. The facilities, such as Itrax™ scanning, radiocarbon dating, Pb-210, Cs-137, Plutonium 239/240, stable isotopes, are widely used by the next generation of Quaternary Scientists. The use of nuclear techniques in Quaternary studies was part of the proposal for the Forum for Nuclear Cooperation in Asia project on climate change. The project aims to bring regional nuclear organisations closer to their collaborators by providing nuclear based techniques in the study of archives of Paleoclimate. ANSTO became the default leader of this project, as we have a proud history in providing exactly that kind of research service to the Quaternary community. It also brought me back to Lake Suigetsu (October 2019), not long after my life-changing double bypass surgery. I did ask myself "how did I get here".

After my recent retirement, I now work on a few projects with good palaeoclimate records in Indonesia and Thailand. I will remain an honorary ambassador for both AINSE and ANSTO.

Some more reading on Lake Suigetsu and radiocarbon calibration:

Bronk Ramsey, C., Staff, R.A., Bryant, C.L., Brock, F., Kitagawa, H., van der Plicht, J., Schlolaut, G., Marshall, M.H., Brauer, A., Lamb, H.F., Payne, R.L., Tarasov, P.E., Haraguchi, T., Gotanda, K., Yonenobu, H., Yokoyama, Y., Tada, R., Nakagawa T. (2012). A Complete Terrestrial Radiocarbon Record for 11.2 to 52.8 kyr B.P. *Science*, 338(6105), 370-374

Grootes, P., van der Plicht, H. (2021). Hessel de Vries: Radiocarbon pioneer from Groningen. *Radiocarbon*, 1-15. https://doi.org/10.1017/RDC.2021.63.

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Nakagawa, T., Tarasov, P., Staff, R., Bronk Ramsey, C., Marshall, M., Schlolaut, G., Bryant, D., Brauer, A., Lamb, H., Haraguchi, T., Gotanda, K., Kitaba, I., itagawa, H., van der Plicht, J., Yonenobu, H., Omori, T., Yokoyama, Y., Tada, R., Yasuda, Y. (2021). The spatio-temporal structure of the Lateglacial to early Holocene transition reconstructed from the pollen record of Lake Suigetsu and its precise correlation with other key global archives: Implications for palaeoclimatology and archaeology. *Global and Planetary Change*, (202), 103493., ISSN 0921-8181, https://doi.org/10.1016/j.gloplacha.2021.103493.

Reimer, P. (2021). Evolution of radiocarbon calibration. *Radiocarbon*, 1-17.https://doi.org/10.1017/RDC.2021.62.

de Vries, H. (1958). Variation in concentration of Radiocarbon with time and location on earth. *Proceedings of the KNAW (Royal Dutch Academy of Sciences)*, B61, 1-9.

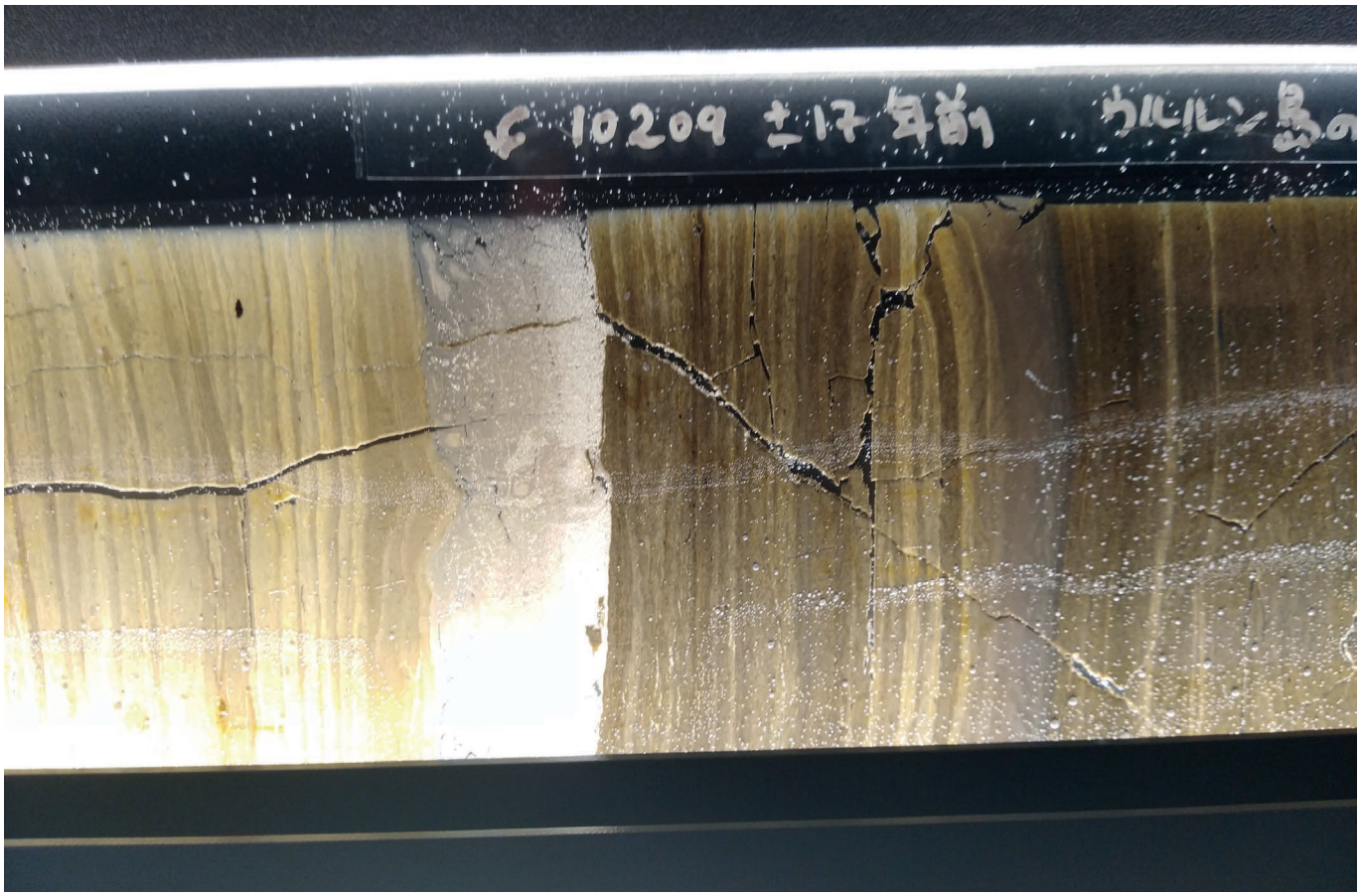
Clockwise from Above Left

Figure 3: The ultimate Quaternary geek merchandise: Lake Suigetsu Varved Tie.

Figure 4: Edible Lake Suigestu merchandise: layered varve cake.

Figure 5: View of the Varve Museum, Fukui prefecture, Japan.

Figure 6: Detail of Lake Suigetsu sediment core at 10209 years ago.



IN PURSUIT OF OLD DIRT – SEARCHING FOR PALAEOENVIRONMENTAL ARCHIVES IN THE KIMBERLEY

Teresa Dixon[1], Rachel Rudd[1], Jordan Brook[1], Hamish McGowan[1] and Nik Callow[2]

1 School of Earth and Environmental Sciences, The University of Queensland
2 School of Agriculture and Environment, The University of Western Australia

In late July 2021, amidst Covid-related border uncertainty, a team of five from the University of Queensland and the University of Western Australia set out across the country on a field campaign to the Kimberley region in north-western Australia. As part of an ARC Linkage Project LP170100242, led by Professor Hamish McGowan and with funding from Rock Art Australia, our goal was to collect terrestrial sediment archives to construct a palaeoenvironmental history of the Kimberley. The Kimberley experiences intense seasonality from the Australian Summer Monsoon, and has a rich archaeological history, which our research aims to contextualise.

Our first stop was Birrindudu Station, a cattle station on the northern edge of the Tanami desert, on Warlpiri and Gurindji country on the Northern Territory's western border. Finding favourable sites for coring in the arid southeast of the Kimberley is challenging, and despite seeking out the wettest areas of the station, including wetlands and lakes, coring proved difficult. The toughest corer we had with us, a Wacker driven percussion corer, had trouble penetrating the hard, clay-rich sediment. Unfortunately, at our third sampling site at Birrindudu station, getting the pipe into the ground proved to be the least of our worries, and we were unable to retrieve a section of core using the block and tackle we had used at other sites. The legs of our tripod began to bend, shackles were warped out of shape, and still the core would not budge – we realised it was time to start digging. One day, and a 1.7 m hole later, we retrieved the hard-won core.

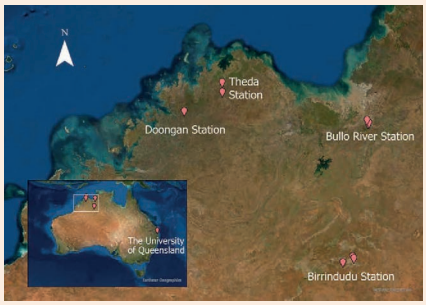
Bullo River Station, on country of the Miriuwung and Gajerrong people in the northwest of the Northern Territory, was our second stop following a detour to Darwin to drop one of our number at the airport. With the memory of the hole-digging still fresh in our minds, we were hopeful for softer sediment. Sure enough, within twenty-four hours of arrival, we had collected two >2.5 metre cores. Under present conditions, Bullo River receives significantly higher annual rainfall than the Northern Tanami, where Birrindudu Station is located. A key aspect of our research will be to establish how vegetation and rainfall has varied along this latitudinal gradient through time.

On our fourteenth day in the Northern Territory, we arrived at the border to Western Australia, only to be told that we would not be able to cross until midnight so that we had spent a full 14 days in the Northern Territory – we needed to cross on the fifteenth day. Keeping spirits high, we visited nearby Keep River National Park for a rest afternoon and an explore. Midnight found us – albeit with slightly lower spirits – making our second attempt at the border, but again we were turned back as we needed to wait until Western Australian midnight, which is 90 minutes after midnight in the Northern Territory. It was a relief when we finally managed to cross into the elusive Western Australia and arrived at our Kununurra accommodation at 1 am.

The final stage of our fieldwork was in the north-western Kimberley at neighbouring Theda and Doongan stations on Wilinggin country, reached after a bone-shaking, skull-rattling drive along the heavily corrugated Gibb River Road. On these properties we visited and collected sediment cores from rainforest patches – lush, dense areas of vegetation which are distinct in the otherwise seasonally dry landscape, and are found on springs, seeps, and creek lines. The sediment cores from these sites have a higher organic composition than those from Birrindudu and Bullo River stations and will be an interesting comparison to the sediments collected from the east to assess spatial variability in past climatic conditions. This region houses a long and diverse sequence of rock art – during our time sampling in the area, we found ourselves wondering what the landscape was like at the time the art was produced, and it is exciting that our research aims to shed light on this.

After a sad farewell to a beautiful part of Australia, we had a solid seven days of driving ahead of us back to Brisbane. In contrast to our outward trip, there were thankfully no border hassles. Fieldwork in the time of Covid is certainly challenging, and it isn't lost on us how fortunate we were to be able to travel and undertake fieldwork. With a bit of border luck, and generous and accommodating hosts, we returned to campus after 5 successful weeks in the field, with over 11,000 km on the odometer, a trailer full of sediment cores, a coating of bulldust and only one bruise.

We acknowledge the Traditional Owners and their custodianship of the lands on which we work and pay our respect to their Ancestors and their descendants. Thank you to Rock Art Australia for supporting our research. Thanks also to Jordan and Grace at Birrindudu Station, Catherine at Bullo River Station, Cecilia at Theda Station, and Kim and Ross at Doongan station for their warm welcomes and for accommodating a bunch of dusty earth scientists.



Above - Figure 1: Sampling locations during fieldwork – inset map shows position of the University of Queensland

Clockwise from Top Right

Figure 2: The field team at Birrindudu Station, after a week of sampling
(Photo: Hamish McGowan)

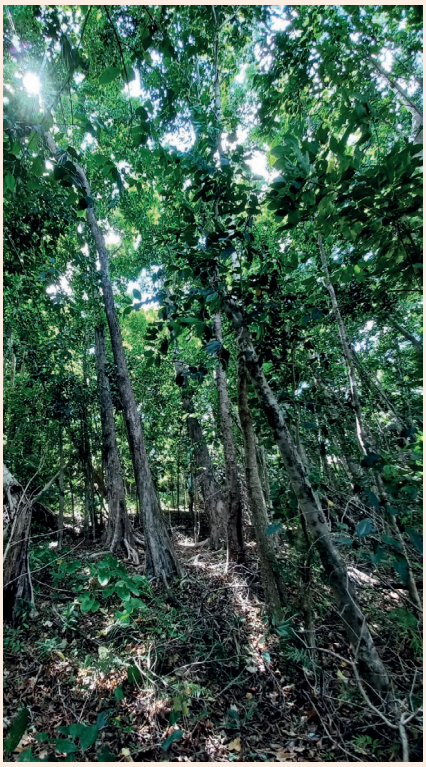
Figure 3: Coring at Birrindudu station with an audience of locals
(Photo: Rachel Rudd)

Figure 4: Early stages of the core retrieval process at Birrindudu station – we're going to need a bigger hole

Figure 5: Coring at Bullo River Station
(Photo: Rachel Rudd)

Figure 6: Collecting D section samples at Station Creek Rainforest, Theda Station
(Photo: Rachel Rudd)

Figure 7: Boundary Rainforest at Theda Station
(Photo: Rachel Rudd)



AQUA CONFERENCE REPORT

Lucinda C. Duxbury

Department of Earth Sciences, The University of Adelaide, North Terrace, Adelaide, Australia

Australian Centre for Ancient DNA, The University of Adelaide, North Terrace, Adelaide, Australia

ARC Centre of Excellence for Australian Biodiversity and Heritage (CABAH), The University of Adelaide, North Terrace, Adelaide, Australia

This year's AQUA conference was my first time presenting my work to a scientific audience outside of my own lab group and it got my brain buzzing. So much science! As a fresh M.Phil student, my mind was pulled in so many different directions – from turbidites to archaeological sites.

There was, however, one caveat. It was online.

Not sure about everyone else but I'm over Zoom. I would have preferred to be in the room. What I would have given to have chased you up after your talk and picked your brains like I pick my samples for charcoal! That said, we've been lucky with Covid in Adelaide. We got together in a lecture theatre and watched as a group. Even still, it felt surreal presenting to a dozen real-life humans but then remembering that the audience was actually several times this size. It was an emotional rollercoaster as I oscillated between 'hey this is heaps chill, just chattin' with my friends' and 'argh! Panic! Don't say anything stupid because those scientists who are really smart are watching you (but you can't see them) hmm... maybe just go home and don't talk at all?'.

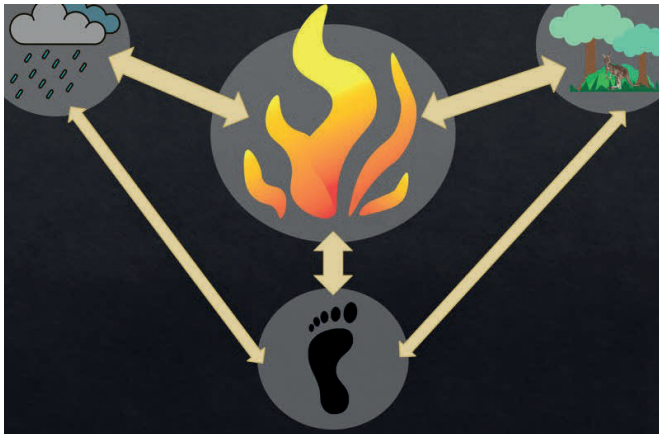
In the end, I didn't go home. In the end, I did present. And in the end, the talk actually went ok. Does anyone else remember similar feelings their first time presenting at a conference?

It was clear that some have already mastered the online arena. Gilbert Price is obviously a Zoom-pro and was somehow presenting from inside his slides and Simon Connor used a live audience survey to get us thinking about common misconceptions about Australia's pre-invasion vegetation. Although, of course, the conference was not without a healthy dose of comic relief from some upside-down presenters and accidental screen shares. I know I certainly forgot how to use a mouse when it was my turn to speak.

More seriously though, as a young woman aspiring to embark on a career in research, I was particularly buoyed (or should I say girled?) by the focus on addressing the glaring gender disparity in science. While the gender diversity amongst postgraduates and ECRs in AQUA isn't bad, it's clear that the pipeline is leaky as we progress up the hierarchy.

Personally, I'd love to hear more stories of prominent women in our field. The more I see these women taken seriously by our community, the more I feel confident that I will be taken seriously too. Thank you to everyone involved in starting this conversation. I am excited to contribute as it continues. I trust this is just the start of a broader dialogue about how we can foster all facets of diversity including racial, ethnic and cultural diversity. Diversity in researchers begets diversity in research. And that can only be an asset.

Anyway, that's about it from me. See you in real life at next year's conference in Radelaide?



Top - Figure 1: A representation of the interconnectivity of climate, ecology, humans and fire discussed in Lucinda Duxbury's talk.

Above - Figure 2: The Adelaide hub enjoying the AQUA conference.

AQUA CONFERENCE REPORT

Nicholas R. Patton

School of Earth and Environment, University of Canterbury

School of Earth and Environmental Science, University of Queensland

In July 2021, around 100 participants took part in this year's AQUA conference. Like many organized events over the last two years, the once in-person meeting was converted to an all-online event. As a result, presentations were given from a variety of locations including, but not limited to: work offices, hotel rooms, private homes and local AQUA hubs. Nevertheless, that did not stop a great line-up. Those who attended were able to experience two days of diverse presentations on an assortment of topics ranging from "*understanding human impacts on ecosystems*" to "*applying geochemical proxies to changes in climate*".

This was the first time I had the opportunity to attend an AQUA conference. I was eager to be able to share some of my PhD thesis findings with the AQUA community. The work I presented was on using surface roughness to determine coastal dune ages at K'gari (Fraser Island) and the Cooloola Sand Mass, Australia (Fig 1a). I was particularly excited about this work because 1) it provides a rapid and systematic method to fill in chronological gaps across landscapes and 2) the applications highlight the influence of climate and sea level variability with landscape evolution.

My presentation, along with the presentations of Jenni Hopkins, Emma Rehn, and Lucinda Duxbury, were selected for the carbon-14 internship award sponsored by the Centre of Excellence for Australian Biodiversity and Heritage (CABAH). This award offers us a hands-on experience to run pre-treatment and radiocarbon measurements on 10 samples at the University of New South Wales Chronos ^{14}Carbon-Cycle Facility. The samples I plan to select for radiocarbon dating will support my on-going work to understand the dune field's evolution. Specifically, the project will aim to constrain terrestrial fire records and transport processes by targeting stratified charcoal layers preserved in depositional foot slopes of dunes (Fig 1b-d).

Despite this being my final year to attend the AQUA conference as a student, this will certainly not be my last. AQUA has lived up to its reputation for being an approachable, inclusive and supportive scientific community. I am grateful to have had the opportunity to learn about all the great projects that are happening across the disciplines, and the insights that I gained from this year's conference will undoubtedly influence my future work and research. With any luck, I hope to see everyone next year in person.

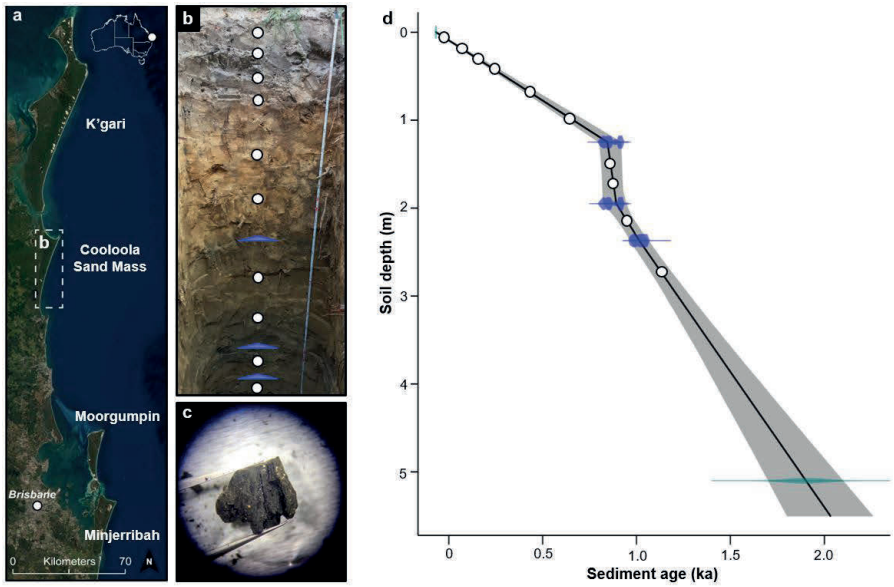


Figure 1: a) Aerial imagery of the South East Queensland dunefield. b) Depositional foot slope profile of a 2.1 ka dune with location of proposed samples (white dots) previously dated c) charcoal samples (blue triangles). d) Preliminary age-depth model determined in R-Studio.

INCLUSIVITY AND EQUITY IN AQUA

Haidee Cadd and Lynda Petherick

The Australasian Quaternary Association (AQUA) Executive Committee has started to consolidate previous efforts by facilitating a discussion on how to improve the inclusivity and equity of the association. Building on earlier work by Barrows (2018) and Reeves (2018), for example, we seek to encourage participation, both across the broader community, but also within the committee, of underrepresented groups. As a first step towards improving the equity of the association, AQUA wished to understand the demography of the society (Table 1), whether members feel welcome within the society, and what improvements they would like to see within the society. The society asked members registering for the recent online AQUA 2021 conference to anonymously answer a series of questions, receiving 194 responses. The preliminary data from this survey of respondents was presented at the AQUA AGM held during the lunch break of the 2021 online conference. The AGM was well attended (89 members) and began a productive and thought-provoking discussion. At the AGM, several new committee members were nominated and successfully appointed, including Annie Lau (UQ) as a specific representative to actively promote inclusivity and equity. Many other members of our community also raised their hand to be involved. If you are keen, please add your name to the table in this Google doc: https://docs.google.com/document/d/12h9SCEJGFI8ITophnPQ6aeouwDkuNcvY3U3V3tkBTR0/edit Thank you to those who already have expressed interest!

	Male	Female	Not Answered	Total
Australia	67	93	3	163
New Zealand	19	12	0	31

Table 1: Number of respondents to the AQUA survey by Country and Identified Gender (note: "Not Answered" indicates participants did not provide an answer). The total number of respondents was 194.

In the following article we will discuss the data that sparked much of the AGM discussions and are helping to contribute to our understanding of the demography of the AQUA community.

The academic/Senior Scientist and mid-career researcher (MCR: here defined as 5-10 years post-PhD) categories are dominated by members identifying as male, while early-career researchers (ECR: here defined as 0-5 years post PhD), students and those in other careers (often outside academia) are predominately members identifying as female (Figure 1). These data support the qualitative assertions that have previously been suggested within the AQUA community, e.g. "I guess this is reflective of the overall scientific demographic (or specifically Earth/Environmental sciences), but it often feels like AQUA is made up of a lot of old men and a lot of younger women" – feedback from a male academic during the survey.

In addition to the data that show males make up the largest proportion of academics and MCRs, males dominate the retired members of the community and those who hold permanent positions. Female members, however, are more commonly employed outside academia or universities, on fellowships or on short term contracts (1-5 years). The overwhelming disparity between male-dominated senior members and female-dominated early-career researchers (and students) suggests that attraction to the discipline and aptitude are not the issues leading to gender inequity within the Australasian Quaternary sciences, but the retention and promotion of female Quaternarists (Figure 2).

During the open forum at the AGM, suggestions to aid in the retention of women included recognizing pioneering female Quaternarists, supporting female members through workshops and seminars and providing childcare or family-friendly conference options. Many members were supportive of the development of a mentorship program within the broader AQUA community, both for students and ECRs, but also for female MCRs or Academics across the level B – C academic ranges to reduce the loss of females across this career stage. The AQUA Executive Committee is currently working on developing a mentoring program for all members of the community, and would appreciate any feedback suggestions from the

community (email lynda.petherick@vuw.ac.nz). This December 2021 *Quaternary Australasia* edition is a dedicated edition to highlight and celebrate the female members of AQUA, both past and present.

In addition to wanting to reach gender parity across all career stages of AQUA, expanding the discussion to improve the levels of all underrepresented groups in our community is an important goal for the society. Of the survey data received, 79% of respondents identify as European/pakeha, while <1% of respondents are of Indigenous Australian or Māori descent (Figure 3).

Further to this, the majority of members in the AQUA community work on Aboriginal, Torres Strait Islander, Māori or Pasifika lands. As suggested in the conference forum, by appropriately engaging with local communities and Traditional Owners we could outline ways of incorporating communities into our research to build their capacity. This was further emphasized by responses to the survey – "Involving more Indigenous Australians and respecting their knowledge systems would be a progressive way for AQUA to move", "We could do a better job of engaging with Indigenous Australians and Māori" and "Perhaps there are still gains to be made on Indigenous recognition (particularly in research practice)." As noted by an Indigenous academic AQUA member during the forum: "There are lots of things we could be doing to advocate better research practice and engagement that both empowers Indigenous people and builds capacity. The long game will see more Indigenous people engaged and involved in science."

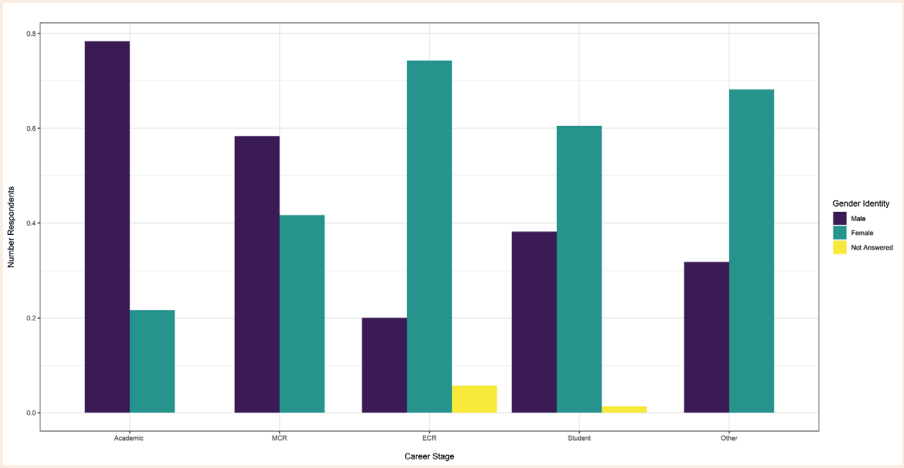


Figure 1: MCR=Mid-career researcher (5-10 years post PhD), ECR=Early-career researcher (0-5 years post PhD), Student = PhD/Masters/Honours/Undergraduate students, Other = those who do not fit within the listed categories.

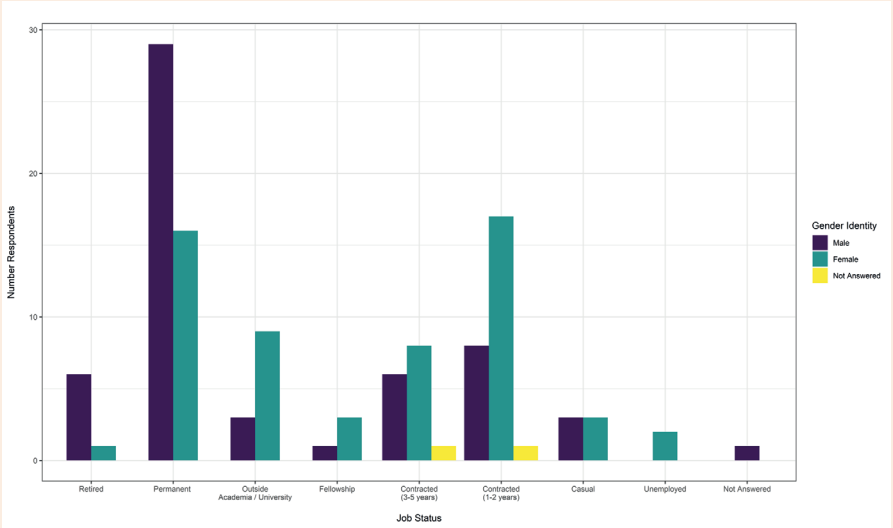


Figure 2: Survey respondent job status (not including students).

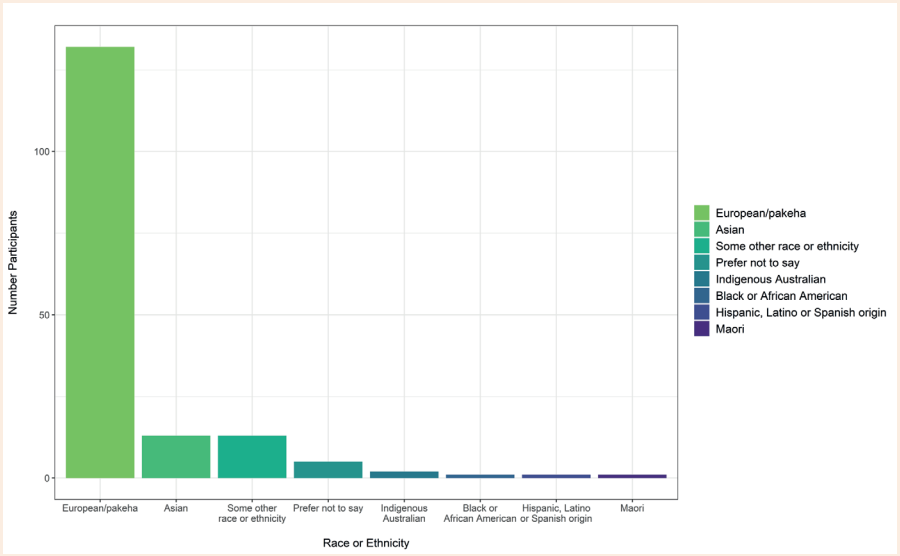


Figure 3: Ethnicity distribution within AQUA.

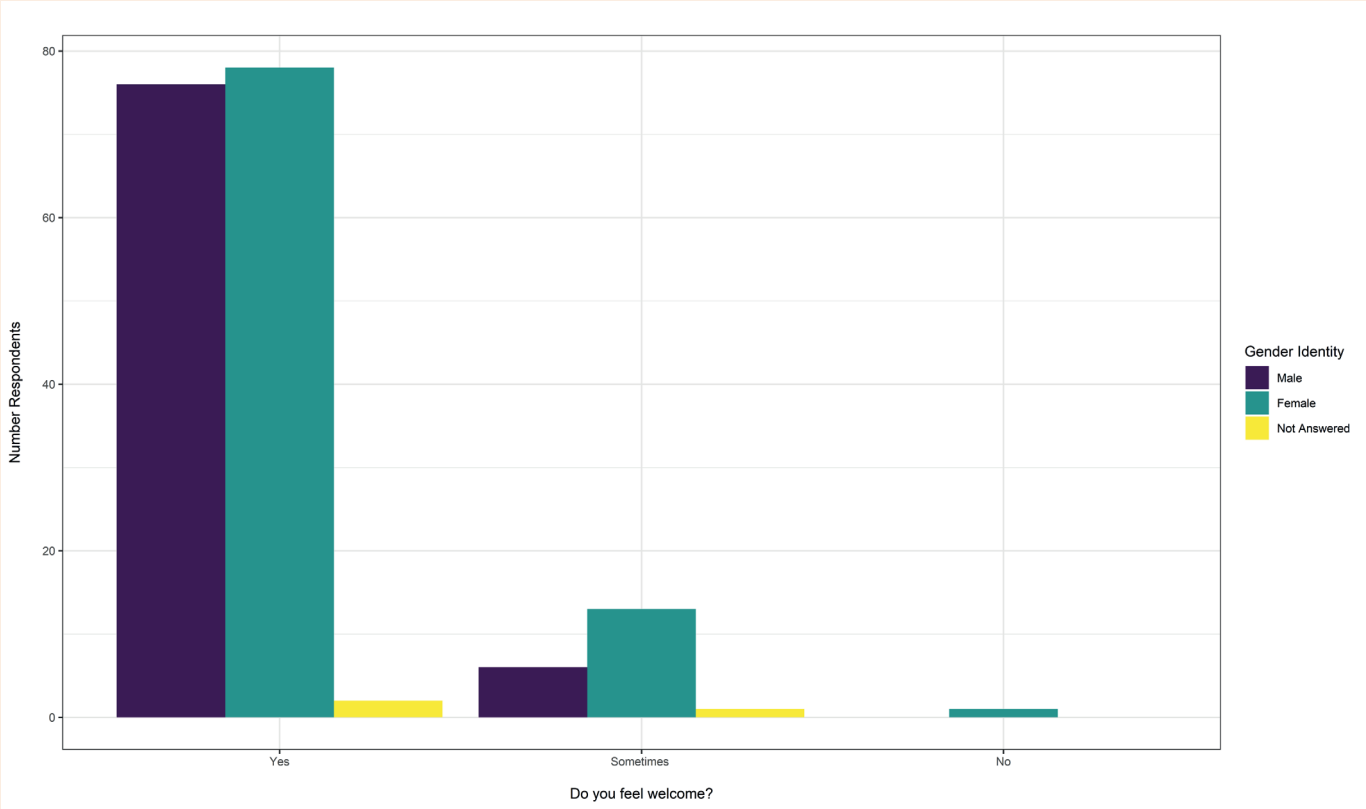


Figure 4: Survey responses to "Do you feel welcome within the AQUA community?"

Central to improving the equity and diversity of an organization is ensuring that all members feel welcome to participate and contribute. Of those who responded to the question "Do you feel welcome within the AQUA community?" 88% responded yes, 11% responded sometimes and <1% responded no. Females were twice as likely to answer "Sometimes" or "No".

Survey respondents indicate a general sense of welcomeness within the society – "I have always felt the AQUA community has been very inclusive, and aims to be more accommodating every year", "This is a pretty friendly association and I enjoy the fact that students and ECRs are very much involved with the association", "I'm glad to be a part of this wonderful community and continue learning in a very inclusive atmosphere", "I felt included from the very beginning, as a student keen to engage". However, as a society we can always strive to achieve better – "I have always felt a home in the AQUA community, but I think we could do better at inclusion and diversity", "Perhaps there are still gains to be made...on inclusivity of different genders and identities (ethnicity, sexuality, etc.)".

The AQUA Executive Committee is actively working on ways to improve the inclusivity and diversity of the organization. The committee welcomes feedback and input into these important issues from all members of the community.

FURTHER READING

Barrows, T. (2018). Participation in the 2018 AQUA biennial meeting. *Quaternary Australasia*, 36: 19.

Fletcher et al. (2021). Indigenous knowledge and the shackles of wilderness. *PNAS*, 118(40), e2022218118.https://doi.org/10.1073/pnas.2022218118.

King et al. (2018). Māori oral histories and the impact of tsunamis in Aotearoa-New Zealand. *Natural Hazards and Earth System Sciences*, 18, 907–919. https://doi.org/10.5194/nhess-18-907-2018.

Reeves, J. (2018). Gender balance and AQUA conferences – A conversation. *Quaternary Australasia*, 36: 21.

PIONEERING FEMALE QUATERNARISTS OF AUSTRALASIA

Helen Bostock

University of Queensland

INTRODUCTION

With the increasing understanding that diversity is critical for research communities to achieve their full potential, there has been significant discussion during the last 2 AQUA virtual meetings in 2020 and 2021 (due to COVID) about the diversity of the AQUA community and how we can increase it in the future. There are currently no female recipients of AQUA lifetime awards.

To find out more about the contributions from pioneering female Quaternarists, a call was put out on social media (the AQUA Facebook page) and on the AQUA email list to solicit suggestions for pioneering female Quaternarists (including academic scientists, technical support and other roles). There was a really positive response, with lots of nominations for inspirational females who have contributed in many different ways to the study of the Quaternary from technical and field support to teaching and mentoring, as well as in the development and running of AQUA organisation and building of the AQUA community.

Here I have compiled the summaries sent in by contributors to highlight the work of pioneering female Quaternarists that are now mostly retired (although some are still active) or deceased and I would like to thank everyone who contributed information or photos. This list of pioneering female Quaternarists is ordered alphabetically and is by no means exhaustive. We would love to hear more about female Quaternarists that were inspirational to you, or who contributed significantly to this field in the Australasian region – please send short articles to the Quaternary Australasia editors (editor@aqua.org.au). I hope to follow up this article with another in the future highlighting the amazing work and achievements of active senior female Quaternarists. I personally am very grateful for these pioneering women who have paved the way and have been an inspiration for future female (and male) Quaternarists.

I appreciate that there is more than just gender diversity and I would love to hear more about the contributions of Indigenous and minority groups to Quaternary studies in Australasia.

DR BETH GOTT

Dr Beth Gott is a plant physiologist and ethnobotanist who is an Honorary Research Fellow at the School of Biological Sciences, Monash University. She taught at universities in the U.S.A. and Hong Kong before joining Monash University in the early 1980s. Her particular area of interest and expertise is the traditional significance and uses of Indigenous Australian plants, challenging the white-centric views of botany and advocating for Aboriginal land management practices. Gott has written many papers on the use of indigenous plants in south-east Australia and was the first to develop a comprehensive database of Aboriginal plant food knowledge. She planted her first Aboriginal plant garden on the Monash campus in 1985. Beth also contributed significantly to undergraduate student excursions and Quaternary research. In 2017 Beth was made a Member of the Order of Australia for 40 years of service to the biological sciences as an ethnobotanist specialising in the study of the use of native plants by Indigenous people.

Figure 1: Dr Beth Gott

(Contribution from Peter Kershaw and the Encyclopedia of Australian Science and Australian Geographic)

CHRISTINE KENYON

Christine Kenyon was first introduced to the Quaternary and AQUA in her 3rd year geography field trip when Peter Kershaw took his Quaternary Studies class to Mildura, which also included a trip to Lake Mungo. This was clearly a life-changing moment and she continued on to do an Honours with Peter Kershaw and Beth Gott. She then began her PhD project (part-time) at the University of Melbourne in 1994 under Dr Ian Thomas, who had just become the AQUA President. The previous Treasurer had resigned and there were no volunteers so Ian decided that Christine should be the AQUA Treasurer, which later on included Membership. Paper renewal notices went out by post and records were kept manually.

At the 1991 Mallacoota conference, a resolution was passed to incorporate AQUA. It is important for an association to be incorporated, so Christine completed the process for the incorporation of AQUA which is why AQUA is incorporated in Victoria. This also required the rewriting of the constitution (since rewritten and available on the AQUA website). AQUA was flush with funds so with then President, Paul Hesse, we started the Student Travel Grants, in the first instance for students to have extra funds for overseas conferences. This was later expanded to cover local conferences.

In 2000 Australia brought GST and no one wanted to be Treasurer. The paperwork and trying to sort out the regulations was left again to Christine Kenyon to sort out. Finally, in 2003, she resigned as AQUA Treasurer at the 2003 New Zealand conference when Janelle Stevenson took over as Treasurer. In 2007, Allan Chivas asked Christine to the be the Treasurer for the

Figure 2: Christine Kenyon

INQUA 2007 conference in Cairns and she was involved in the planning and organisation of this large international conference.

Unfortunately, Christine never did finish writing her part-time PhD project, as life got in the way, but over the years she has worked as a Research Assistant and demonstrated in Geomorphology practical classes. She currently volunteers at the Melbourne Museum where she transcribes historical documents from their Alfred Howitt Collection and volunteers at the Royal Botanical Gardens, Victoria at Cranbourne. She is also currently assisting Michael Fletcher with the historical aspects of his Indigenous Fire Project.

GILL ATKIN, DAPHNE MOSS, JUDY OWEN, ELIZABETH GEISSLER AND JOAN GUPPY

In 1983, Gill Atkin joined Biogeography and Geomorphology in the Research School of Pacific Studies, the Australia National University, running the pollen processing lab and producing thousands of high-quality samples before her retirement in 2005. In the early 1980s she was part of a strong female team that included Daphne Moss, Judy Owen, Elizabeth Geissler and Joan Guppy. These women were skilled botanists, researching and producing numerous pollen records from some of the most important sites and landscapes in our region, such as Lake George, Lake Barrine, Bega Swamp and the Central Highlands of New Guinea. Along with Gill, they also undertook experimental work and were instrumental in maintaining and expanding the Australasian Pollen and Spore reference collection (APSA), a resource that remains an incredible legacy for those working in the field today. With retirements and career moves came new team members.

Our community owes much to these highly skilled technicians and researchers. They brought with them exceptional botanical and ecological knowledge as well as an eye for detail and a gift for patient problem solving. Through their open collegiality, they provided generous support to PhD scholars, early career researchers and numerous international visitors. Their legacy is still felt today in the department now known as Archaeology and Natural History, ANU.

(Contribution from Janelle Stevenson in conversation with Gill Atkin)

PROF. JANE SOONS

Jane Margaret Soons got a scholarship to the university of Sheffield to study Geography and also spent 5 months studying Geomorphology at the University of Strasbourg. In 1958, she was the first woman PhD graduate in Geography at the university of Glasgow. After tutoring at 2 British universities, she became fed-up with being overlooked for academic positions and heard about a lecture position at the University of Canterbury. In the geography department at the University of Canterbury she felt accepted and her hard work led to promotion and research opportunities and eventually to a promotion to professor in 1971, the first woman professor at the University of Canterbury and possibly the first in New Zealand. For many years she was the sole female academic member of staff. She is nationally and internationally known for her investigations of glacier-sculpted landforms especially in the Rakaia Valley and environmental change in the central South Island of New Zealand. She was the Head of School from 1990 until she retired in 1993. She was also the president of the International Union of Quaternary Research and convenor of the National Committee for Quaternary Research for the Royal Society. In 1988 she was awarded the David Livingstone Centenary Medal for Southern Hemisphere Research (American Geographical Society) and in 1994 the Royal Society Silver Medal. In 2001 she was awarded the distinguished New Zealand Geographer Medal and was given an honorary Doctor of Science from the University of Glasgow in 2009. She was a role model and is remembered by her students and colleagues for her kindness and support of their work, as well as her enthusiastic lectures and mentoring of young geomorphologists and future generations of female scientists.

Figure 3: Professor Jane Soons

Figure 4: Professor Jane Soons building

Jane Soons passed away in September 2020 at the age of 89. A celebration of her lifetime's contributions was undertaken on the 10th June 2021, including the renaming of the University of Canterbury's Geography Building in her honour.

oration_soons.pdf (nzgs.co.nz)

(Jane Soons – Wikipedia)

DR JEANETTE HOPE

Dr Jeannette Hope is a vertebrate paleontologist and archaeologist. She studied zoology at the University of Sydney, with an Honours project studying the physiology of tuataras. Following her Honours she got a teaching scholarship at Monash and started her PhD with Prof. Jim Warren. For her PhD she investigated the effects of the repeated flooding of Bass Strait on the speciation of a rat kangaroo genus, *Potorous*. This included extensive field work on islands in the Strait such as Hogan, Deal, Flinders and Cape Barren Islands. Funding was very limited, although she was awarded an Ingrim Grant that provided a few hundred dollars. Luckily the islands are hospitable and she was able to use a farmhouse on Flinders Island while she excavated Ranga Cave, finding a natural 8000 year sequence that was rich in faunal remains, including potoroos. The project also collected fauna in northern Tasmania and analysed museum specimens for south-eastern coastal Australia.

In 1977 she attended the ANZAAS meeting in Melbourne and was enthused by the talks of archaeologists and geologists such as the young Jim Bowler. Jim Peterson, a geomorphologist at Monash University, started a Quaternary discussion group with meetings in Melbourne; Jeannette was a key member of this group.

In 1973 Jeannette, together with Bruce Thom, established and were the inaugural editors of the Australian Quaternary Newsletter (forerunner to Quaternary Australasia). The aims of the Newsletter were to report on:

1. Symposia or special publications of specialist societies with interests in the Quaternary
2. The activities of the newly formed Quaternary Groups in Western Australia, Victoria and Canberra
3. Facilities available to people working in the Quaternary, the most important of course being radiocarbon laboratories
4. Books and other publications relevant to the Quaternary research. AQN_No1_March_1973.pdf (aqua.org.au)

They had to overcome the resistance of then members of the 'establishment', i.e. the Australian Academy of Science's National Committee for Quaternary Research, who felt that this organisation was sufficient to represent the Quaternary community.

Jeannette was very interested in Quaternary change and cave deposits. She published an early paper on a date from a mummified thylacine from the Nullabor (Partridge, 1967). She saw the problem with changing surnames and all her later papers, reports and chapters have been published using her married surname after she married in February 1968.

She received her PhD in 1968 and moved to Canberra in late 1968. She started a job in the Department of Prehistory at ANU, where she created a zooarchaeology lab and developed the collection that spanned the Pacific and New Guinea as well as Australia. She spent several months in 1969 and 1970 in New Guinea examining the fauna on Mt Wilhelm. Work at ANU included faunal analyses in Cloggs Cave and other sites being excavated by Josephine Flood. She also worked at Mungo with Alan Thorne, on Kangaroo Island, and excavated a death trap at McEacherns Cave on the Glenelg river in south-western Victoria.

She also worked for the New South Wales National Parks and Wildlife Service (NPWS). She undertook a range of different research work typically linking cultural heritage, archaeology, and palaeontology, publishing extensively on western New South Wales. She also contributed to issues of gender in archaeology. Jeanette played a big role in helping to establish the AQUA and the Quaternary community. She was a regular participant in AQUA meetings and lead several field excursions.

Partridge, J. (1967). A 3,300 year old thylacine (Marsupialia: Thylacinidae) from the Nullarbor Plain, Western Australia. *Journal of the Royal Society of Western Australia*, 50: 57-59.

(Contribution from Geoff Hope and Peter Kershaw). Jeannette Hope – Wikipedia

JOAN COWLEY AND HEATHER SCOTT-GAGAN

While technicians are not always recognised for their contributions to research, much of the work by students and researchers could not have happened without their knowledge and dedication to running instruments and keeping the labs ticking over. We owe much to the many technicians who have prepared and analysed Quaternary samples. Joan Cowley and Heather Scott-Gagan are two technicians who ran the ANU's Research School of Earth Sciences (RSES) stable isotope lab between 1997 and their retirement in 2017, producing tens of thousands of stable isotope measurements on corals, speleothems, foraminifera, and more. Their dedication to the MAT-251, one of the first dual-inlet mass spectrometers, saw it continue to function from many years, outlasting many other instruments of its kind. However, their contribution went way beyond technical skill and they were very much engaged in the science they were part of; their enthusiasm, commitment, and institutional knowledge were critical to turning research ideas into reality. Their steadfast service and extraordinary attention to detail in the lab led to new discoveries in Quaternary science. Heather and Joan's incredible depth of knowledge and creative ingenuity meant there was a solution for any problem. Their office was always open, whether you needed a good vent or another pair of eyes on a challenging dataset. Looking back on their careers, from laughter-filled morning teas crammed in their tiny office, to puzzling out strange voltage readings from the mass spectrometer, these women and their contributions have had a profound impact on the research, career success, and well-being of countless students, visitors and academics.

Figure 5: Joan and Heather at Liang Luar cave

(Contributions from Ali Kimborough and Michael Gagan, Gavin Dunbar, Linda Ayliffe, Chris Turney and Helen McGregor)

"Joan and Heather taught me the value of careful laboratory and analytical work. The importance of this lesson cannot be overstated – the science we produce is only as good as the data it's built on. But producing quality data is not as easy as it seems. There are skills in hand-eye coordination to weight that tiny sample to exactly the mass needed. Repeatedly. There's careful standardisation and being suspicious of 'funny numbers' and having the expertise to recognise funny numbers. There's troubleshooting a temperamental mass spectrometer, over the phone, late on a Saturday night. And then there's cups of tea. And sometimes cake. I pass on the lessons I learned from Heather and Joan; it all starts with good data. "
Helen McGregor

DR JOCELYN M POWELL

Dr Jocelyn Powell completed her PhD thesis in 1970 in the Research School of Pacific Studies at the Australian National University on "The Impact of Man on the Vegetation of the Mt. Hagen Region, New Guinea". The research involved pioneering approaches to integrating ethnobotany, ecology, and stratigraphic and palynological studies of lake and swamp sites in the Wahgi Valley – a key location associated with archaeological investigations that were ongoing at the early agricultural site of Kuk Swamp in the highlands of Papua New Guinea. The results shed light on the deep antiquity of human influence on the mountainous tropical environments of Papua New Guinea and paved the way for future studies into the ethnobotany, archaeobotany, palynology and palaeoecology of the region.

Jocelyn was deeply interested in traditional plants used for food, medicine, and as tools of traditional cultivation in Papua New Guinea. During the early 1970s she was based at the University of Papua New Guinea and worked with UPNG students from the Mount Hagen area to gather material for a monograph on "Agricultural Traditions of the Mount Hagen Area", published in 1975. Soon after this, Jocelyn took up a position at the National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, where she worked for many years on systematic botany, including a number of genera within the Epacridaceae. Throughout the 1980s Jocelyn continued to publish on the vegetation history and the origins of agriculture in Papua New Guinea and many of these works continue to have a huge impact on the field of Quaternary tropical palaeoecology.

(Contribution from Simon Haberle)

LUCY CRANWELL

Lucy Cranwell is a New Zealand botanist responsible for pioneering work in palynology. She studied English and Botany at the University of Auckland, followed by a Masters in Botany with a thesis on epiphytes. During her university days she developed a love of tramping which came in handy later on when she undertook many botany field trips with her friend and fellow botanist Lucy Moore, to various remote and inaccessible parts of New Zealand wilderness. A few weeks after graduating in April 1929, she was offered the inaugural Botany Curator position at the age of just 21. The museum was due to open in November that year and it needed displays. As well as finding botanic specimens for display she also organised the Cheeseman Herbarium of ~10,000 specimens. Over her 14 years as the Botany Curator, she collected over 4000 plants for the herbarium. During a trip to Europe to attend the International Botanical Congress in Amsterdam in 1935, she was invited by Professor Lennart von Post of Stockholm to learn his method of fossil pollen analysis. With knowledge of this new field of palynology, Lucy opened up a whole new field of botany in New Zealand. Her work analysed pollen taken from sediment bogs, revealed the past botanical assemblages in New Zealand, and aided in the understanding of the supercontinent Gondwana. She was made a fellow of the Linnaean Society in 1937, and the same year was awarded the Loder Cup (NZ premier conservation award). She was elected a fellow of the Royal Society of New Zealand in 1944 (second woman to be elected) and was the first woman to be awarded the Hector Medal from the Royal Society of New Zealand in 1954. In 1944 she moved to the USA with her husband and after initially working at Harvard University, she became a research affiliate in palynology at the University of Arizona, Tucson.

The New Zealand native grass species *Festuca luciarum* is named after both her and Lucy Moore. She is also credited with encouraging a love of botany in a generation of Auckland children through her "botany trots", taking children to places like Rangitoto Island, and she wrote weekly short articles for children about plants for the Auckland Star Newspaper. The New Zealand Association of Scientists Cranwell Medal is awarded to a practising scientist for excellence in communicating science to the general public in any area of science or technology to honour Cranwell, a remarkable communicator of science in a time when this was essentially unheard of.

Lucy Cranwell – Wikipedia

DR MAUREEN LONGMORE

Maureen studied Environmental Science and Palaeoecology at Ulster University in Coleraine. She moved to Australia where she worked as a Research Fellow at the Department of Prehistory, Biogeography and Geomorphology at the Australian National University and later as a Senior Lecturer at the University of Adelaide. She worked on Lake Tyrrell in NW Victoria and pioneered research on Fraser Island including the first all-female expedition to the island to core perched lakes. She used a range of tools to study lake sediment records including Caesium 137 dating and palynology. She conducted research on a range of lakes including Hidden Lake and the Old Lake Coomboo depression. She also undertook research on the Coorong in South Australia. Although not a huge publication list, the papers she has are very highly cited.

Maureen was unorthodox and innovative. She had a "can-do" attitude and her science was driven by curiosity and a passion for exploration. Confidence and optimism were the essence of Maureen. She did not recognise boundaries such as gender expectations, nor hierarchy within the department. Her wit and charm with landholders was legendary. Maureen was an educator first and an academic second; she would take long lunches with the postgraduates to discuss the essence of life and engage in a broad range of discussions. She had a huge impact on all of the students she taught and supervised and was an inspiration to many. Maureen passed away in January 2017.

(Contribution from Kathryn Taffs, Janelle Stevenson, Justine Kemp and Henk Heijnis)

Anecdote from the all-female Fraser Island Expedition led by Maureen (as told by Gill Atkin).

Base camp for the coring trip was a remote 'shed' in the middle of the island and it is worth noting that Maureen knew the island 'like the back of her hand'. One night there was a knock at the door. There on the doorstep was a group of men.

"Hi. Are any of the blokes around? We seem to be lost".

"Indeed you are," replied Maureen as she calmly closed the door.

"She taught me so much more than science, including a love for Fraser Island lakes and Border Collies. I feel fortunate to have received her guidance, and have embraced her holistic view of life, a form of science driven by curiosity, and a passion for exploration with no boundaries." – Kathryn Taffs

Figure 6 and 7: Dr. Maureen Longmore

DR MERNA MCKENZIE

Dr Merna McKenzie's interest in palaeoecology started at the University of Melbourne while studying botany in 1945. She then spent many years as a school teacher before returning to Monash University in 1969 to complete a MSc in Environmental Science. She then continued on to do a PhD on the Late Quaternary vegetation and climate in the central highlands of Victoria, Australia, with special reference to *Nothofagus cunninghamii (Hook) Oerst*. After her PhD she continued in an honorary capacity to undertake her own research on the highlands of Victoria and to contribute her botanical and palynological expertise to other projects, especially with students for over 30 years. Merna currently holds the position of Adjunct Research Fellow in the School of Earth, Atmosphere and Environment, Monash University.

Figure 8:
Dr. Merna McKenzie in her element. Photo supplied by Peter Kershaw.

In 2015 Dr Merna McKenzie was nominated and awarded the Order of Australia Medal (AOM) for her contribution to education and research in palaeoecology, particularly the application of fossil pollen, plant macrofossil and charcoal analyses to the reconstruction of the history of vegetation, climate, and forest fires from continuous lake and swamp sediment cores in Australia. Merna presented results of her research at many national and international conferences as well as in some 17 peer-reviewed papers.

An outstanding feature of Merna is the way she has maintained her enthusiasm for and dedication to palaeoecological research and instruction over the last 35 years. A more general appreciation of Merna's character as a guiding light in the School of Geography and Environmental Science is exemplified by her recent selection as the motivating speaker at the annual student prize award ceremony. Merna was an inspirational role model to all, especially women, young and old, and was nominated by a number of AQUA members.

(Contribution from Peter Kershaw and the nomination for the AOM)

DR ROBIN LORRAINE CLARK

Robin Clark completed her PhD thesis in 1976 in the biology department at Monash University on the "Vegetation History and the influence of the sea at Lashmar's Lagoon, Kangaroo Island, South Australia, 3,000 BP to the present day". The initial core from Lashmar's Lagoon only managed to core partway through the sediments, so she then revisited the site in 1977 and managed to core to the basal sands. The Lashmar work indicated the abandonment of Flinders Island around 3800 years ago and the effect of fires and floristics.

Robin invented the point-count charcoal method that basically kicked off the study of fire history in Australia. Many of Robin's papers are to do with the taphonomy of micro charcoal production, including a highly referenced methodology paper.

She went on to work for CSIRO LandResearch (Bob Galloway, Bob Wasson) for a few years, including an advanced study of fire history at Rotten Swamp. Most of her publications were reports and book chapters.

At CSIRO she became increasingly dubious about pollen analysis and the scientific basis for palaeoecological claims in general, including our 'optimistic' primitive age modelling based on hunches and keeping the dates we 'like'. She also pointed out that the error for a pollen percentage becomes (appallingly) larger if fewer grains are encountered. She had a change of career and took a job with the Department of Health and spent several years in Darwin.

(Contribution from Geoff Hope)

DR SUZANNE DUIGAN

Dr Suzanne Lawless Duigan was one of Australia's pioneer palynologists. She undertook her degree BSc and MSc at the University of Melbourne between 1942 and 1946; she then moved to the UK to do her PhD at the University of Cambridge Botany Department, collaborating with Harry Goodwin. She then returned to Australia to become a lecturer at the University of Melbourne's School of Botany where she worked until she retired. She undertook research on pollen morphology and Quaternary palynology of the Lake Mountain and Macquarie Island. Her work and knowledge facilitated significant subsequent research and aided many subsequent Quaternary palynologists.

A summary of her life can be found in the Australian Journal of Botany Vol. 45 No. 3, 1997. on 'Australian palaeoclimates: refinement of estimates from palaeobotanical data'. Wikipedia article: Suzanne Duigan – Wikipedia

DR YVONNE BONE

Dr. Yvonne Bone is a sedimentary geologist, geochemist, palaeontologist, and oceanographer whose research contributed to the understanding of Australia's Quaternary marine environments. A native Australian, she grew up on Wardang Island but went to school in Adelaide. She was a professional florist while raising a family and went to Adelaide University in middle age. She did her Honours B.Sc. and PhD at the University of Adelaide and subsequently got a job as a lecturer at the University of Adelaide. She was an avid teacher, and students were constantly in her office. She was the mentor of numerous research students and HDRs from across the world many of whom are now university professionals themselves. Her students always speak glowingly of her, especially her teaching abilities and caring nature. Her original research focussed on the origin of Precambrian uranium deposits in the Northern Territory. However, she was always intrigued by sedimentology and living things and subsequently turned her research interests to the carbonate rock record.

Figure 9: Dr Yvonne Bone

Focussing first on Proterozoic successions, she gradually moved on to understanding the modern carbonates of offshore southern Australia today. Her research is truly extensive, ranging from oceanographic studies to marginal marine and lacustrine landforms, to the origin of comparatively recent limestone deposits and to palaeontology of marine and terrestrial biota. These on-land studies range from eastern Victoria, throughout South Australia, across and beneath the Nullarbor Plain to the coast of Western Australia. She has been senior scientist, chief, or co-chief scientist aboard research vessels offshore. These productive research cruises have examined the seafloor in both the Indian and Southern oceans. Her research on living and fossil bryozoans is internationally recognised and stands as a landmark in this field. This science has led to over 30 co-authored scientific papers published in international journals. These results have also been integrated into two co-authored books entitled *Neritic Carbonate Sediments in a Temperate Realm* (2011), and *Biogenic Sedimentary Rocks in a Cold Cenozoic Ocean* (2021), both published by Springer Nature.

She has remained an avid gardener. When visiting her house, surrounded by a flourishing garden and numerous fruit trees, she will always take the visitors first to the garden to show off recent changes in the foliage. She is a charming and outgoing person with a quick smile and immediate interest in the activities of others. A lover of great music, she is a classically trained pianist that also sang in the Adelaide Symphony Orchestra chorus.

(Contributions from Noel James and Linda Nothdurft)

A NEW VERSION OF THE ONLINE DATABASE FOR POLLEN AND SPORES IN THE ASIA-PACIFIC REGION: THE AUSTRALASIAN POLLEN AND SPORE ATLAS (APSA 2.0)

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ABSTRACT

Advances in the fields of environmental, health and biological sciences often are built upon access to high quality reference collections that support ongoing research and generate future research endeavours. Traditional approaches to archiving and using pollen and spore reference collections have relied on onsite use and hardcopy exchange of material which is time consuming, labour intensive and is unsustainable over long time periods. The building of a digital pollen and spore reference collection into a widely accessible online Atlas is emerging as a fundamental resource needed across these wide fields of research. We have built a digitally archived and searchable online reference collection of key Australasian pollen and spore grains that will provide a critical resource to support emerging areas of high profile research including work in: airborne allergens and respiratory disease; past, present and future environmental change; evolutionary and systematic biology; biostratigraphy (Cretaceous to Tertiary floras); pollination biology; and forensic sciences. The first generation of the digital Australasian Pollen and Spore Atlas (APSA 1.0) was designed and launched at the Australian National University in 2007. After 14 years of service to the palynological research community the site was disestablished due to site instability and security issues. This led to a new APSA 2.0 platform, launched in 2021, that is (i) more stable and secure, and (ii) will include improved modes of data upload enhancing its functionality and relevance for a wide range of disciplines.

INTRODUCTION

The construction of regional pollen and spore databases in the northern hemisphere and in the southern hemisphere has proven to be invaluable and widely utilized tools for developing new areas for research across a wide range of disciplines (e.g. Bennett and Willis 2001; Marchant et al., 2002; Vincens 2007). Most notably in the field of past climate and vegetation change there has been a great deal of effort into constructing multi-proxy reference databases that not only provide access to pollen and spore images, but bring fossil site data and modern and past distributional data into integrated relational databases. The impact of this effort is reflected in emerging high-profile outcomes in palaeoenvironmental research (Mottl et al., 2021).

In Australia, existing collections of pollen and spore types are fragmented and there has been little attempt to co-ordinate or integrate this information. The Natural History section of Archaeology and Natural History (ANH), School of Culture, History and Language, Australia National University, holds the largest collection of modern pollen of Southeast Asia-Pacific-Australia in the world, amounting to 14000+ taxa from the region (Biogeographic range of the ANH Pollen Collection, Figure 1). This collection has been developed through a long-term research effort at the Australian National University in palaeoclimatology, palaeoecology, archaeology and more recently in aerobiology (Stevenson et al., 2007; Haberle et al., 2014) and continues to support high-profile research outcomes in the ANH research areas (e.g. Mottl et al., 2021; Long et al., 2021). Smaller collections are held at other institutions including Monash University (Monash Pollen Database, ~4000 species from Australia and Southeast Asia), University of Newcastle (~2000 species from Australia, Shimeld et al. 2000), University of Queensland (~200 species, School of Earth and Environmental Sciences), the University of Melbourne (~1000 School of Earth Atmospheric and Geographic Sciences and School of Botany) and Australian Nuclear Science and Technology Organisation (ANSTO, ~200 species from Australia). The University of Sydney (~500 species School of Geosciences and the Woolcock Institute of Medical Research, ~200 species with allergenic properties; Hjelmroos et al., 1999), and the University of Tasmania are currently developing an Airborne Allergen database associated with aerobiology research. Botanical information on all species is held in the herbaria

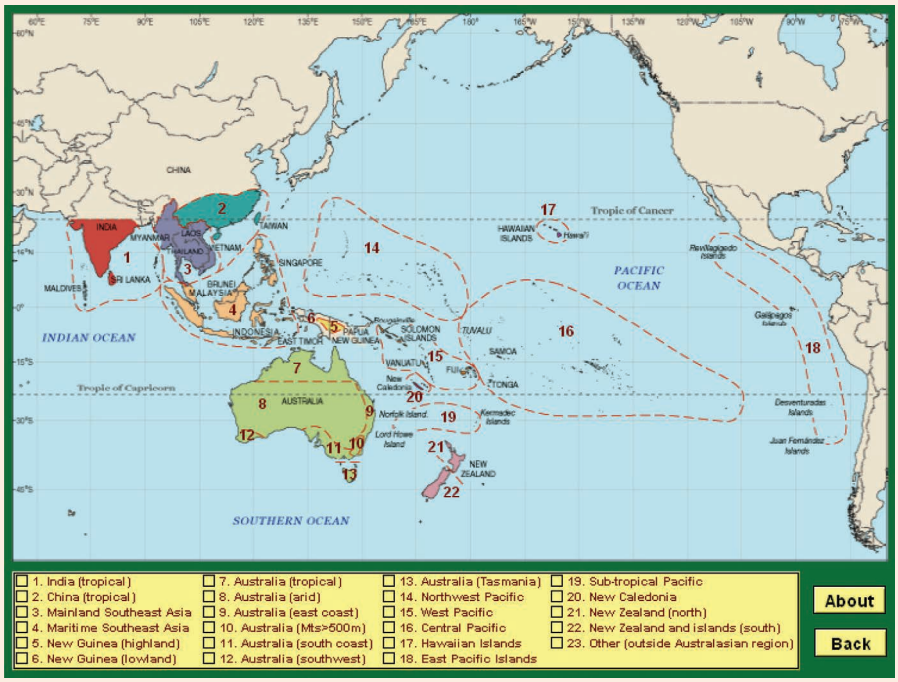

Figure 1: Biogeographic regions represented in the APSA and searchable in the database.

around Australia (mainly at the Australian National Botanic Gardens Canberra and in the emerging online database "The Australasian Virtual Herbarium" https://avh.chah.org.au).

These collections have developed from specific local institution research needs, and in some cases have generated information relational databases associated with specific research aspects of the collections. For example, the ANH Pollen Collection laboratory also hosts the Indo-Pacific Pollen Site Database which collects available data on vegetation change derived from identification of pollen from fossil settings for the area from tropical India through Australia and to Easter Island. The information is available spatially and the results can be interrogated chronologically. This database is a keystone of global programs for testing palaeoclimate models, vegetation change, landscape change and human effects on catchments and fluvial systems. In addition, the ANH initiative has generated a renewed drive to upload pollen data to the NEOTOMA pollen database (https://www.neotomadb.org) with support from the ARC Centre of Excellence for Australian Biodiversity and Heritage (CABAH). A second example is held at the Woolcock Institute of Medical Research, University of Sydney, a collection of 200 pollen and fungal spore species that have been entered into the Airborne Allergen Database (Hjelmroos et al., 1999). This database is designed to assist with the identification of pollen and spores, which are either known to be important species for allergenic reactions in asthma and hayfever, or are likely to be confused with such species. The database is designed to be used by medical practitioners, lab technicians and as a resource for plant industry personnel and has been a key resource for developing airborne allergen studies in the region (Benyon et al. 1999). A common characteristic of all collections is that there exists a large and rapidly growing volume of data associated with the pollen and spore taxa represented, which risks being lost (due to limited funding) or being duplicated (due to disparate locations and/or discipline boundaries).

In order to establish a working database that can function in a multi-disciplinary environment, with the potential to break down inter-disciplinary boundaries, the Australasian Pollen and Spore Atlas is designed to not only have the attribute of enabling continued development of collections of pollen and spore data at independent institutions, but provide a federated platform for development of an interactive and unified database available to the wider professional and novice community. A successful bid for ARC e-Research funding in 2005 (SR0567379, lead CI Simon Haberle) and an ARC LIEF grant (LE0882682, lead CI Simon Haberle) resulted in the initial development of applications to manage large information repositories in intranet/internet information services, data mining and digital image acquisition suited to the tasked required to facilitate the construction and implementation of the database, and finally the launch of the APSA 1.0 in 2007. After 14 years of service to the palynological research community the site was disestablished due to site instability and security issues. This led to a new APSA 2.0 platform, launched in 2021, that is (i) more stable and secure, and (ii) will include improved modes of data upload enhancing its functionality and relevance for a wide range of disciplines.

DEVELOPMENT, IMPLEMENTATION AND IMPACT OF APSA 2.0

HIGH-RESOLUTION DIGITAL IMAGE ACQUISITION AND STORAGE

The quality and resolution of pollen and spore taxa digital imagery that currently exists in the Australasian region is extremely high (Figure 2). We have been able to use state-of-the-art digital cameras to acquire images of approximately 2000 targeted species during the last year and will continue to populate the database at the same time as developing efficient methods for acquisition and storage of the large images produced. These images form the keystone component of the Atlas, and along with the much more voluminous lower quality images that already exist, enhance the research capacity of the database. A critical component of the Atlas will be the incorporation of a taxa identification tool that allows for the professional as well as the technical novice to be involved in pollen and spore identification.

FEDERATION, DATA MINING, DATA ARCHIVING, WEB INTERFACE DESIGN

Accessibility to the large collections of pollen and spore information in the Australasian region is limited by distance between active laboratories and lack of compatibility and/or online presence of existing databases. This part of the database development activity will develop tools for a federated database that is accessible over the web with a straightforward query interface, and is suitable for the professional as well as the technical novice involved in pollen and spore identification. The development of a user-friendly search engine and query interface to the federated database will be key to the success of the Atlas (Figure 3a-d). A wide range of smaller existing pollen and spore databases with associated specific research information can be linked to the APSA. The Atlas will be a flexible and powerful knowledge management tool with the potential to evolve and be applicable to ongoing research development by a wide range of users including those within diverse disciplines such as archaeology, biology, geology, and medicine.

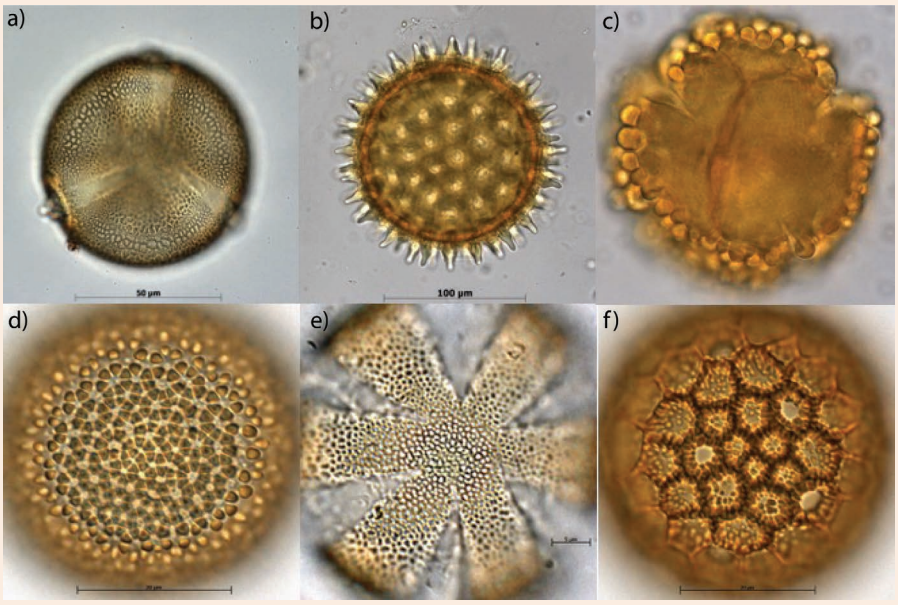

Figure 2: Images of pollen species with accession code found on the APSA database. (a) *Luffa cylindrical* (280-7-1a), (b) *Ipomoea indica* (254-2-18), (c) *Epacris crassifolia* (238-1-11), (d), *Aleurites moluccana* (149-38-1d), (e) *Passiflora aurantia* (204-1-1), and (f) *Polygonum orientale* (75-2-36).

FUTURE RESEARCH AND BENEFITS OF ENHANCED COLLABORATION

The APSA has the potential to play a key role in expanding our capabilities in the area of palaeoenvironmental reconstruction and global change research. The APSA may also contribute to several new research initiatives which are described below, including aerobiology and the impact of pollen on respiratory health, phytogeographic and systematic studies delving into the origin of Australian flora through pollen morphology, and other potential applications in areas of plant reproduction/genetics, agrobiology and forensic sciences. The use of APSA in the area of education, training and science communication is also being developed. The interactions, activities, outcomes and potential research and networking spin offs of this database are outlined in Figure 4.

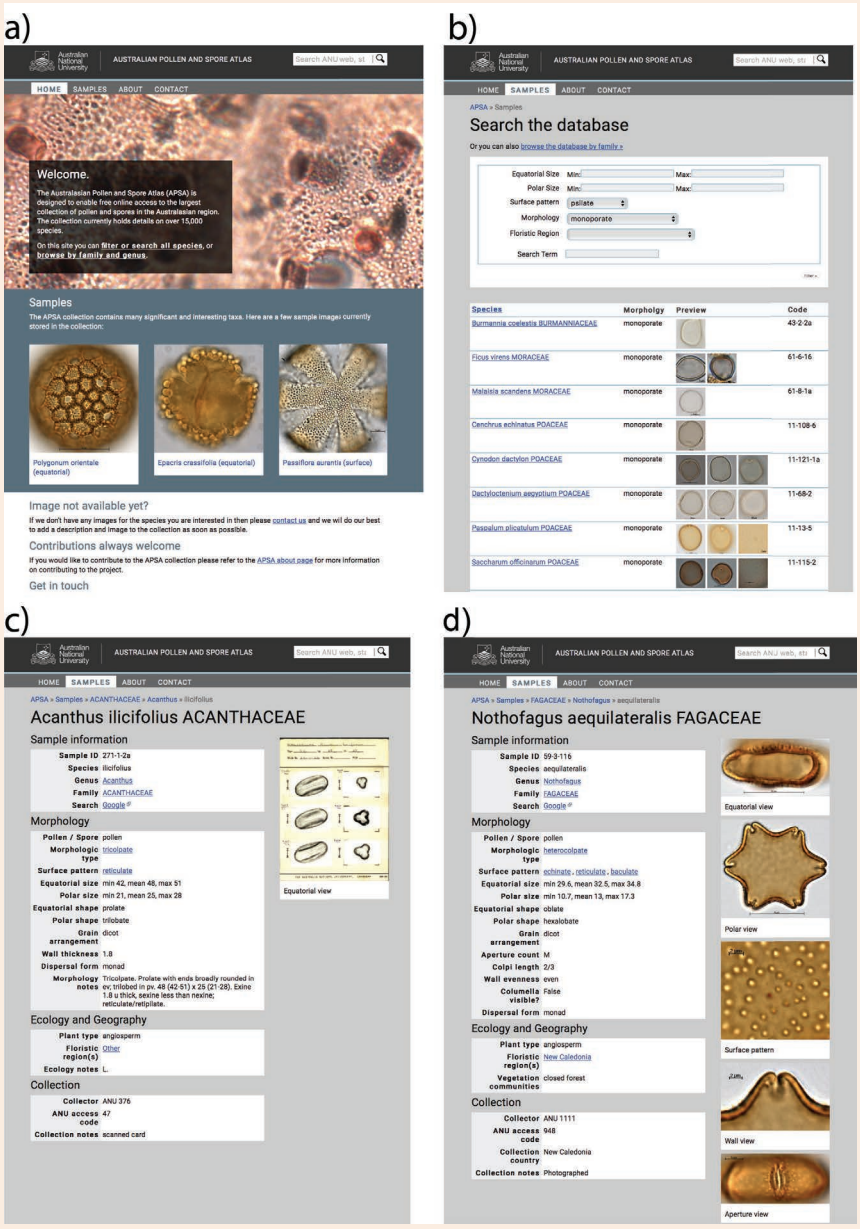

Figure 3: Screenshot of APSA 2.0 output. (a) frontpage of website with key navigation and background information links, (b) example of the search function and capabilities through morphological as well as free text search option, (c) example of single sample with associated information and scanned card image (original in-house format of pollen data management), and (d) example of a single sample with associated information (derived from original slide and associated metadata in the ANH pollen collection).

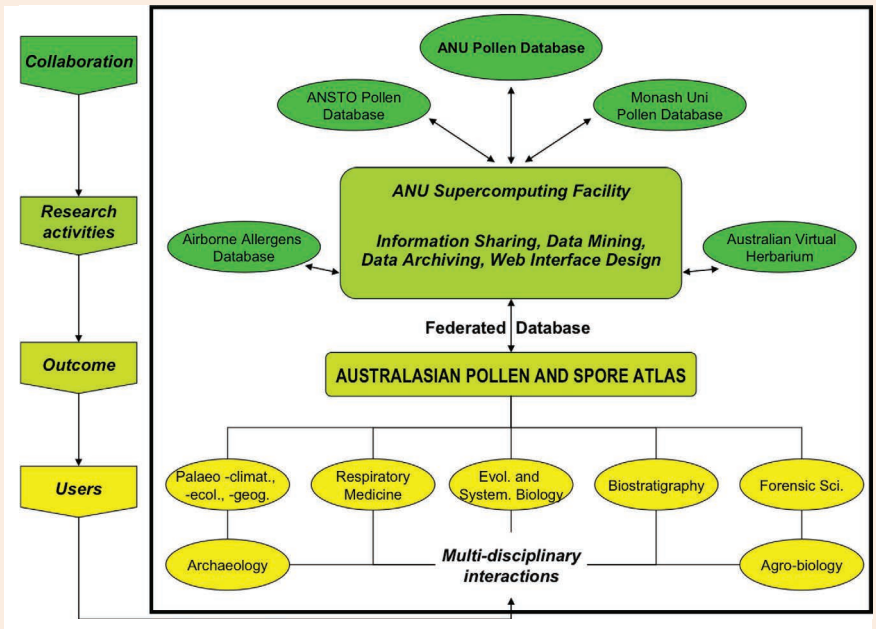

Figure 4: Flow diagram of the proposed collaborators to the database construction activities with a focus on the ANU Pollen Database. These activities lead to the primary outcome of the development of a Federated Database (The Australasian Pollen and Spore Atlas). The predicted users cross a multi-disciplinary field with potential novel interactions that would follow from the development of this resource.

CONCLUSIONS

The development of the APSA will vastly improve the management and distribution of a dataset that has a wide range of potential users from professional to novice levels. The ability of laboratories and institutes to operate virtually and collaborate across huge distances in Australia and internationally hinges on our capabilities in this area. The construction of a secure and sustainable APSA that provides for expansion and evolution of individual pollen collections and associated meta-data is critical to continue to develop high profile research outcomes, facilitate inter-disciplinary project development, and help the next generation of palynological researchers across a wide range of disciplinary backgrounds.

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EVIDENCE FOR SUBSTANTIAL DARLING RIVER FLOWS IS PRESERVED IN 7,000-YEAR-OLD LAMINATED MUDS DEPOSITED AT MONTEITH, LOWER MURRAY RIVER VALLEY: A CHALLENGE TO THE CONVENTIONAL VIEW OF INSIGNIFICANT DARLING RIVER FLOWS DURING THE MID-HOLOCENE

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ABSTRACT

Here, we present arguments that refute the main criticisms made by De Deckker and Murray-Wallace (2021) of the studies investigating the characteristics of the Murray River Estuary during the Holocene that were published in the journal *Scientific Reports* (Helfensdorfer et al. 2019, 2020). We also present geochemical data which demonstrate that significant amounts of Darling River sediment were deposited during the mid-Holocene at a Lower Murray River Valley site (Monteith). At this site, discrete Darling River-derived mud laminae are interlayered with Murray River mud laminae at a time when Darling River sediment is entirely absent from the offshore record. We therefore stand by our interpretation that most of the Murray-Darling River's fine-grained sediment load was captured and deposited within a very-low gradient central basin environment that extended at least 140 km upstream from the Murray River's mouth during the mid-Holocene sea-level highstand.

INTRODUCTION

De Deckker and Murray-Wallace (2021) made three substantial criticisms of our modelling assumptions and interpretations as well as disputing the identification of a transgressive succession of riverine to central-basin sediments which we posit were deposited in the lower Murray River Gorge at Monteith (Figure 1) between ~11,000 and 5,000 years ago during the final stages of the post-glacial sea-level rise and during the mid-Holocene highstand (Helfensdorfer et al 2019, 2020).

Their criticisms are: (1) that our salinity interpretation of the Murray Gorge sediments requires correction because the sediments were deposited when sea level was too low to have entered the Murray Gorge depression; (2) that the sea-level highstand within the region of our study did not exceed +1 m AHD, i.e. one metre below the +2 m value used in our modelling; and (3) that our suggestion that "mid-Holocene climate reconstructions for south-eastern Australia based on fluctuations in the delivery of fine-grained sediment to the ocean offshore the lower Murray River's mouth must be re-evaluated3" is baseless as the climate reconstructions based on marine cores MD03-2611 and MD03-2607 are validated by other studies. This third criticism, in its essence, rejects two of the main findings of Helfensdorfer et al. (2020) which are: (a) that "the mid-Holocene sea-level highstand generated an extensive central basin environment extending at least 140 kilometres upstream from the river mouth and occupying the entire one to three kilometre width of the Murray Gorge"; and (b) that the natural sediment trap generated by the Murray central basin probably "captured most, if not all, of the fine-grained sediment discharged from the 1.06 million square kilometre Murray-Darling catchment... [and] persisted from 8,518 to 5,067 cal yr BP".

Here, in addition to refuting the direct criticisms of our studies, we also present geochemical data which demonstrate that significant amounts of Darling River sediment were deposited at Monteith within the so-called 'Mannum Mud' deposit of the lower Murray Gorge during the mid-Holocene. These Darling River derived sediments were deposited in backwater conditions as discrete 0.5 mm to 5 mm thick laminae interspersed with 0.5 mm to 10 mm thick sediment laminae derived from the Murray River catchment. The presence of abundant Darling River sediment deposited as a significant component of the lower Murray Gorge's mid-Holocene valley fill conflicts with the absence of Darling River material of Holocene age in marine sediment cores taken at deep water sites located on the continental slope approximately 200 km distant from the present-day Murray River Mouth

Figure 1: Location map for the Helfensdorfer et al. (2019, 2020) studies showing the relative position of Monteith, the Narrung Narrows, the Werringee Embayment and the river kilometre distances of townships on the Lower Murray River relative to the Murray Mouth. The inset shows the position of the Lower Murray River segment (blue) within the Murray-Darling catchment (grey shaded area) and the location of marine cores MD03-2607 and MD03-2611 investigated by Gingele et al. (2004, 2007).

(Gingele & De Deckker 2005; Gingele et al. 2004, 2007). This suggests that these offshore cores do not capture a complete record of the Murray River's sediment discharge during the mid-Holocene.

We therefore stand by the assumptions used to inform our modelling, the suitability of those models for answering the research question they interrogated, and the implications that the sedimentary record presented in core Monteith-A has for the understanding of the evolution of the lower Murray River and the Murray's Lower Lake system during the early – to mid-Holocene.

Here, we focus on refuting the criticisms made of our publications (Helfensdorfer 2019 and 2020) by De Deckker and Murray-Wallace (2021) and, for brevity, do not duplicate or reproduce the data and interpretations presented in our original works that were published by *Scientific Reports*. Hence, we encourage readers who are interested in this contested matter to examine our two original papers (Helfensdorfer 2019 and 2020) as well as the other discussion papers that our two works have prompted (Tibby et al 2019, 2020; Hubble et al 2020, 2021). Our responses to the specific criticisms presented by De Deckker and Murray-Wallace (2021) are provided below.

CRITICISM ONE
THE ALLEGED 'MARINE ORIGIN OF MONTEITH CORE-A'S UNIT TWO'

The substance of Criticism 1 is encapsulated in the following two quotes from De Deckker and Murray-Wallace's (2021) critique: i) *"their salinity interpretation of the Murray Gorge sediments requires correction because they were deposited when sea-level was too low to have entered the Murray Gorge depression."* and ii) *"The base of the Murray Gorge at the start of sediment infill was some 16 m below AHD. According to Lambeck et al. (2014), sea level was close to – 40 m at 10 ka BP and this implies that unit 2 in core Monteith-A with a median age of 10,374 cal yr BP could not have been connected to the ocean"* (De Deckker &Murray-Wallace 2021).

There are three significant errors contained within these statements. Firstly, the base of the Murray Valley Gorge at Monteith is located in excess of 30 m below present-day sea level at our study site (Helfensdorfer et al 2020). Core Monteith-A encountered sands between – 20 m AHD and 29 m AHD where the borehole was terminated in weathered bedrock (Figure 2; and Helfensdorfer et al. 2020). Similarly, site investigations for the freeway located near Murray Bridge, ~5 km upstream of our study site also identified the bedrock base of the gorge to be located approximately 30 m below sea level (SARIG 2019).

Secondly, we suspect that the claimed – 40 m location for sea level at ~10 ka refers to the modelled *ice-volume equivalent sea level* in Figure 4 of Lambeck et al. (2014). We suggest that it would be more appropriate for this aspect of their critique to be based on Figure 1 of Lambeck et al. (2014), which presents observed relative sea level, i.e., sea-level estimates more representative of experienced conditions. We have reproduced the Lambeck et al. (2014) Figure 1 relative sea level data within Figure 2 here and highlight the observed relative sea level data for the Australian region generally and the South Australian region specifically. Both our presentation here and the original presentation of Lambeck et al.'s (2014) observed relative sea level data demonstrate that sea level was located ~31 m + 10 m below present-day sea level at 10 ka, both globally and in the Australian region generally.

Thirdly, unit 2 (-20 to – 29 m depth) **is not** interpreted by us to be a marine deposit. We clearly identify it as a terrestrial deposit, a braided river sand (see Figure 2 here and Figure 4 in Helfensdorfer et al. 2020). The uppermost material contained within unit 2 is 10,000 years old and both underlies and pre-dates the unit 4 material marking the transition to the central basin conditions identified in core Monteith-A. At no point do we state that unit 2 is a marine or estuarine unit. Similarly, our *unit 3* (-21 to – 15 m depth) is also interpreted as a terrestrial fluvial deposit that was deposited between 10 ka and 9 ka.

The transition from fluvial to estuarine central basin conditions identified by Helfensdorfer et al. (2020) is represented by unit 4 which presents shelly material and cross-laminated sandy muds. This event occurred at Monteith between 9 ka and 8.5 ka and as it turns out, unit 4 occupies the same interval of elevation (-15 m to – 11 m AHD) indicated by the Australian data as Lambeck et al.'s (2014) global observational record for sea level (Figure 2). The timing of sedimentation identified by Helfensdorfer et al. (2020) is therefore consistent with observed relative sea level data from Lambeck et al. (2014), supporting a conclusion that the rising ocean caused the flooding of the Murray Gorge and back-stepping of near-coastal depositional systems in a landward direction between 9 ka and 8.5 ka. This accords with observations for large river systems globally (e.g., Hori and Saito 2007; Hijma and Cohen 2010, 2011; Rodriguez et al. 2010; Bruno et al. 2017).

We therefore reject this first criticism of our work.

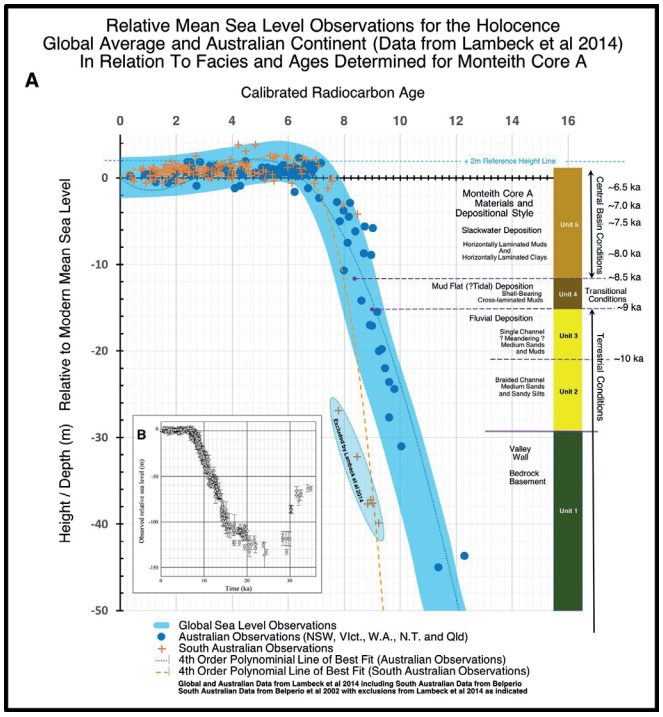

Figure 2: Observed Mean Sea Levels for the Holocene in relation to the time and depth of deposition of sedimentary units identified in core Monteith-A, Lower Murray River, Australia. Sea-level observations are as presented by Lambeck et al. (2014). Fourth order lines of best fit after Belperio et al. (2002), forced through the origin, are included for the Australian and South Australian datasets. These lines of best fit both clearly identify a local, "continental-edge load-stress relaxation induced" mid-Holocene highstand of approximately +2 m, i.e., the value used in the Helfensdorfer et al. (2019, 2020) modelling studies at around 6 ka. Note that the transition from terrestrial fluvial sand deposition to central basin laminated mud deposition (i.e., estuarine deposition) interpreted for core Monteith-A occurs between 9 ka and 8.5 ka at depths from – 15 m + 1m to – 12 m + 1m AHD. Note also that the muddy sediments deposited at Monteith during the 9 ka to 8.5 ka transition period present shells and cross-laminations, features typical of tidal estuarine environments.

CRITICISM TWO
SELECTION OF AN APPROPRIATE SEA-LEVEL ELEVATION FOR MODELLING

Criticism Two disputes the elevation of sea level that was selected to represent the mid-Holocene highstand in our numerical modelling of hydrological flows in the system. De Deckker and Murray-Wallace (2021) state that we do not provide a basis for this value. Our reasoning for its selection was outlined in our 2019 paper and elsewhere (Hubble et al. 2020, 2021) and we provide further detail below.

The models presented in Helfensdorfer et al. (2019, 2020) were designed as end-member representations. They were intended to capture the full-range of possible factors controlling flow through the Murray Gorge in order to identify the variables that best explain the presence of the valley-wide >10 m thick layer of finely laminated clays and muds deposited in the lower Murray Gorge between Wellington and Walker Flat (Hubble & De Carli 2015; Jacksa et al. 2016; De Carli 2019). We did consider the implications of the location of the Lower Lakes (Lake Alexandrina and Albert) as well as the lower Murray River in relation to the continental shelf edge in order to choose an appropriate sea-level value for our mid-Holocene highstand models (Figure 3). We agree with De Deckker and Murray-Wallace that values for the magnitude of the glacio-hydro-isostatic contribution due to inferred relative sea-level rise should be determined from the distance of the site of interest to the shelf-edge and provide the basis for the estimate we used Helfensdorfer et al. (2019, 2020). Figure 3 shows that a +2 m isostatic uplift contour, running parallel to the trend of the shelf edge, passes through Franklin Harbour, Port Gawler and the town of Wellington (located where the Murray River debouches into Lake Alexandrina) and is coincident with the midpoint of our model's spatial

domain. We note the observed sea levels of +2 m and +1.4 m for Franklin Harbour and Port Gawler respectively at 5 ka (Von der Borch & Altman 1979). We submit that the +1 m Coffin Bay estimate that De Deckker and Murray-Wallace (2021) suggest to be a more appropriate value for use in our modelling would be an under-estimate of sea level in our study area during the period of interest and, at the very least, would not represent an end-member of all possible conditions.

The value of +2 m which we used to represent the mid-Holocene sea-level highstand is consistent with Lambeck et al.'s (2014) median globally observed mean sea level value, observed Australian mean sea level values, and the local South Australian mean sea level values (see Figure 2). We note the concerns of the critique, but we are extremely confident that our modelling is based on parameters that replicated actual conditions of the period of interest or conditions materially the same as the conditions extant during the period of interest. Consequently, we reject this criticism.

Criticism 2 also cites Von der Borch and Altman's (1979) paper to assert the existence of a freshwater lake system during the mid-Holocene, which we refute with the following quote from the referenced paper: *"Prior to barrage construction a saline to brackish water environment existed in the area, which would then have been an estuary. Due to the barrages, the area is now lacustrine in character and filled with fresh water. In the ensuing discussion it will become apparent that it is not possible accurately to define from existing stratigraphic evidence whether the area was lacustrine or estuarine in character at any one time in the past."* Further, it has been established that the several sapropel units that De Deckker and Murray-Wallace

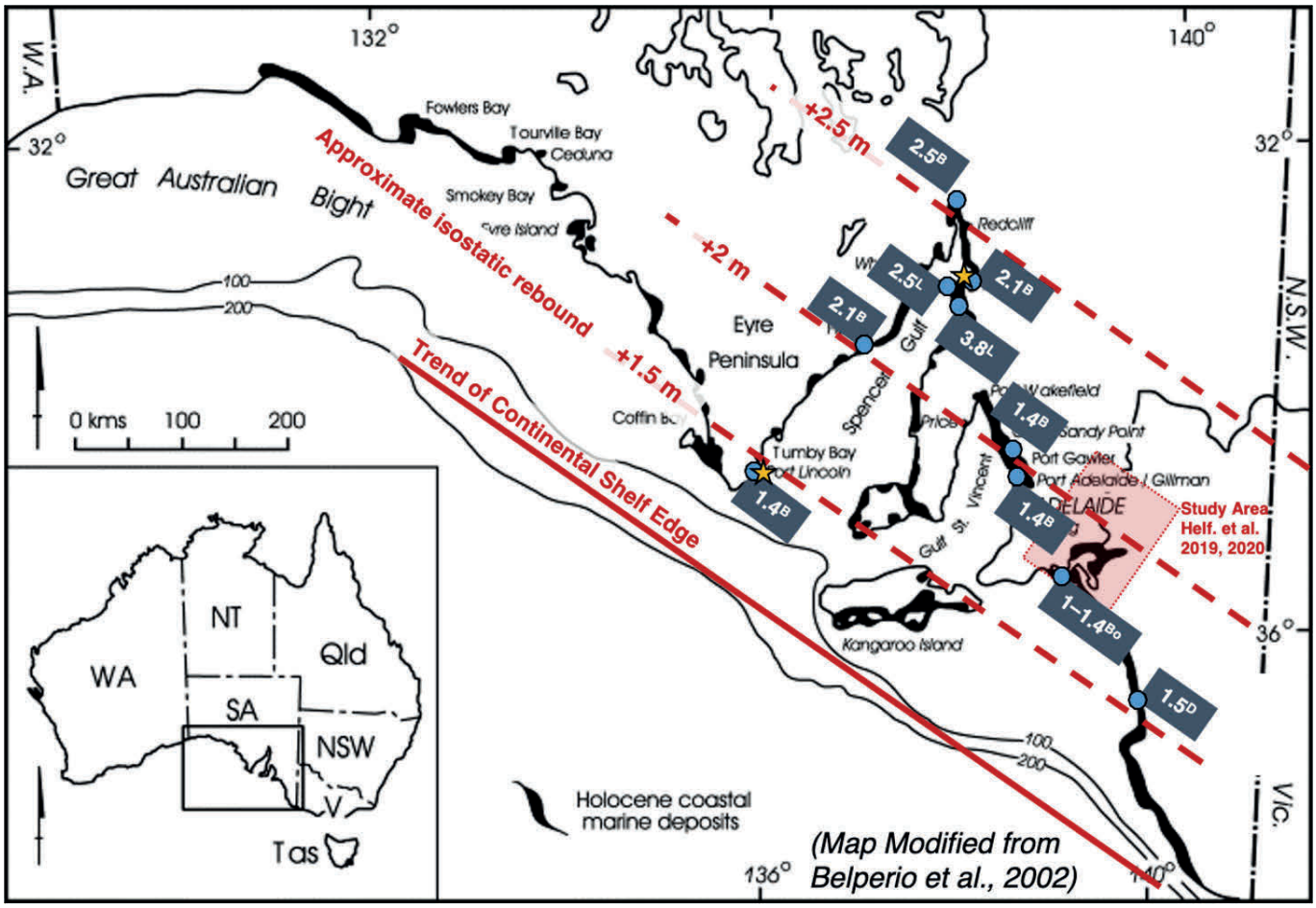

Figure 3: Map of coastal South Australia showing the distribution of indicators for Holocene highstand sea-level elevations presented by Belperio et al. (2002 – B), Lambeck et al. (2014 – L), Dillenburg et al. (2020 – D), and Bourman et al. (2000 – Bo). The maximum-indicated relative sea-level elevation (in metres relative to modern sea level) is shown at each site (intertidal indicators; blue circles and associated labels) as well as approximated isostatic rebound contours (dashed red lines) oriented parallel to the approximate trend of the continental shelf edge (solid red line). We note that mid-Holocene highstand relative sea levels are poorly constrained between Port Lincoln and Port Pirie (gold stars; modelled as + 1 and + 2 m respectively in Belperio et al. 2002), with sea-level indicators proximal to the contour that passes through the mid-point of our study's modelled spatial domain ranging from 1.4 to 2.1 m. (Figure modified from Hubble et al. 2021).

(2021) use to challenge the possibility of brackish conditions in our study area were more likely deposited in freshwater lakes not connected to the primary fluvio-estuarine system and would therefore not retain proxy evidence of the palaeo-estuary's salinity (Job et al. 2021; Gloster 1996). Finally, a more recent palaeolimnological study of the Lower Lakes suggests brackish to salty conditions were extant between 7.9 and 6.0 ka (Haynes et al. 2019). We therefore reject the suggestion that the palaeo-Murray Estuary was exclusively and persistently freshwater between 8.0 and 6.0 ka.

CRITICISM THREE

THE CENTRAL BASIN PROPOSED BY HELFENSDORFER ET AL (2019, 2020) COULD NOT HAVE EXISTED AND THERE WAS NO INTERRUPTION IN FLUVIAL SEDIMENT DELIVERY TO THE OCEAN FROM THE MURRAY RIVER DURING THE MID-HOLOCENE

Several statements in De Deckker and Murray-Wallace (2021) challenge our hypothesis that fluvial sediment delivery to the ocean was interrupted by the formation of a natural stilling basin in the Lower Murray Gorge during the mid-Holocene. The critique entirely rejects our proposition that the mid-Holocene sea-level

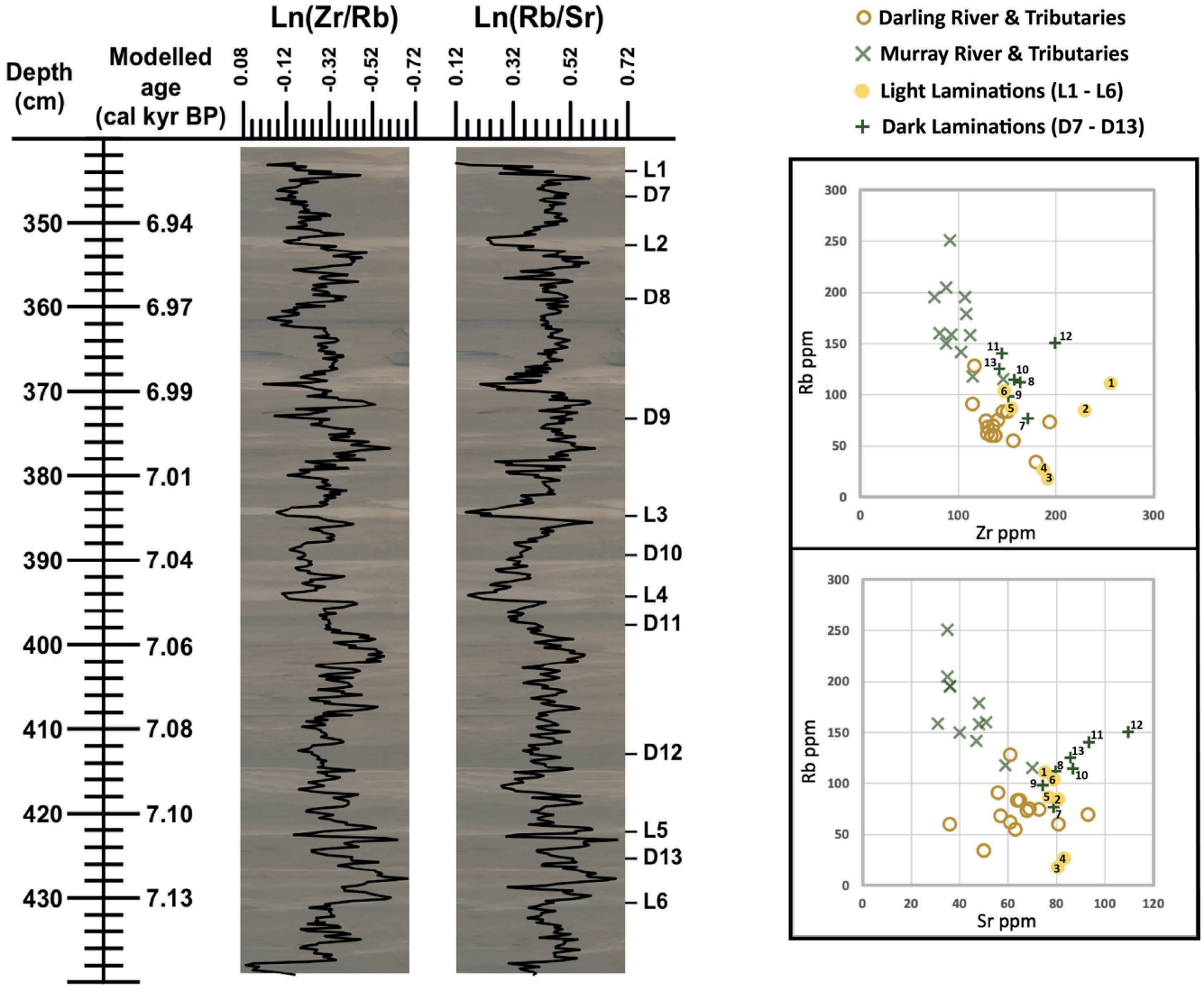

Figure 4: Left: Downcore profiles of Zr/Rb and Rb/Sr ratios determined by scanning-XRF (measured as counts per second) overlaid on optical images that display the delicate, millimetre-scale interlamination of light – and dark-coloured mud layers typically presented by unit 5 muds in core Monteith-A segment 3.4 m to 4.4 m (6.91 ka to 7.15 ka; cf. Helfensdorfer et al. 2020). Data are presented as log-ratios to minimise closed-sum effects (organic matter, moisture content, etc.) on down-core variability. Right: Plots of total Rb vs Zr and Rb vs Sr content for subsamples taken from core Monteith-A (see labels on right hand side of core optical images for subsample locations), compared to clay compositions determined for the Darling and Murray River catchments from Gingele and De Dekker (2005).

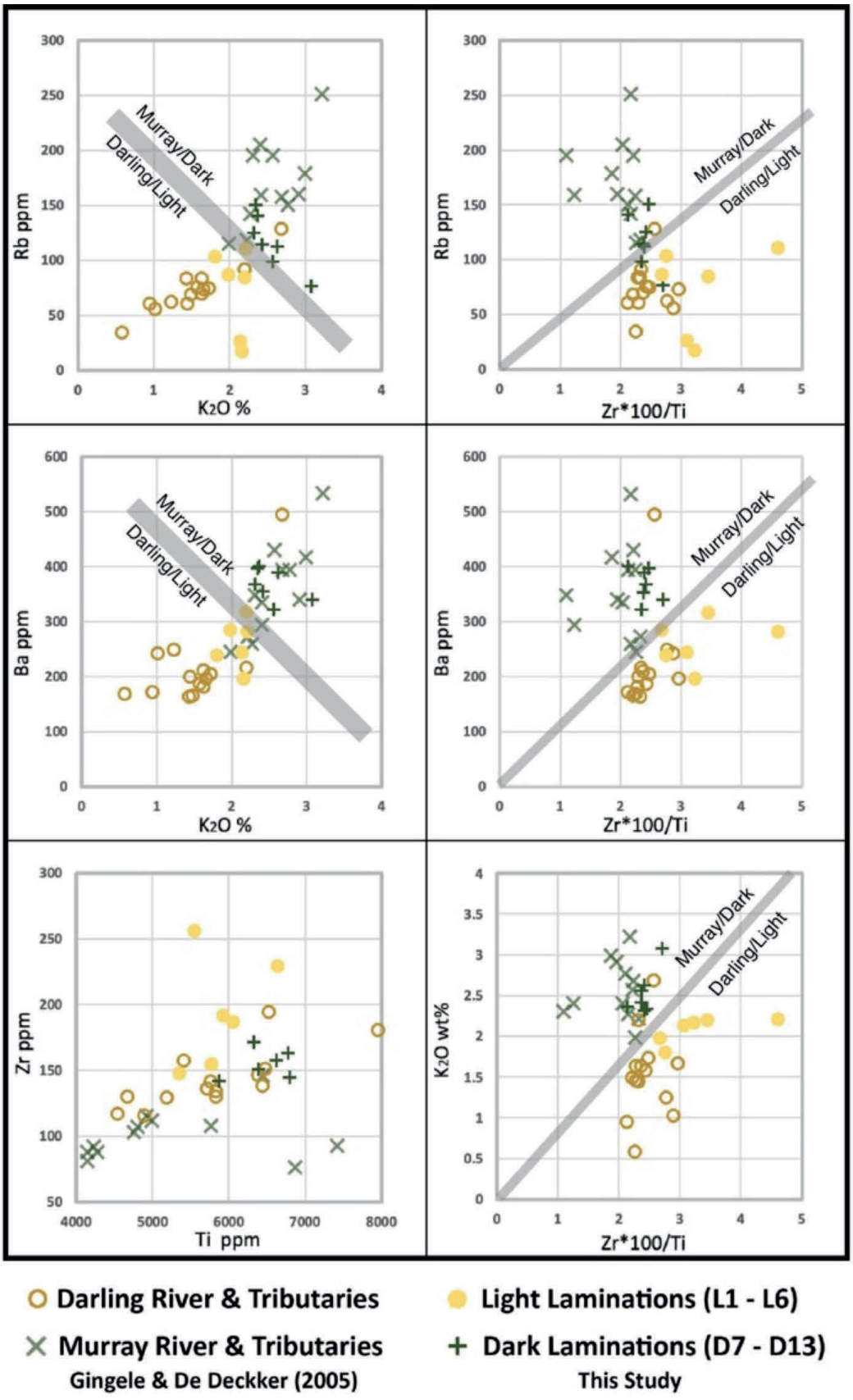

Figure 5: Interelement plots of Ba, Rb, K_2O, Ti, Zr, and Zr*100/Ti for core Montieth-A light and dark lamination subsamples (see core optical images in Figure 5 for sample locations) compared to clay compositions determined for the Darling and Murray River catchments from Gingele and De Dekker (2005).

highstand generated a central basin environment in the Lower Murray Gorge (Helfensdorfer et al. 2019, 2020). This position is summarised by their statement: "the hypothesis that the climatic signals recorded in a deep-sea core offshore from the Murray Mouth 'require revision', is also baseless because their claim that the River Murray sediments could not have reached the ocean is incorrect".

Firstly, we assert that we have not rejected climatic reconstructions presented by others (e.g. Gingele et al. 2004, 2007; Moros et al. 2009) as has been stated in the critique of our paper and note that we suggested that they be "reconsidered". The timing of the onset of aridity in south-eastern Australia that is raised by De Deckker and Murray-Wallace (2021) is irrelevant to our hypothesis and arguments. Rather, based on our results, we question the validity of hydroclimatic reconstructions using proxy signals, e.g., clay/silt ratios and illite concentrations, that require terrigenous suspended sediments to have continuously and consistently reached the continental slope between 17 ka and present (Gingele et al. 2007; De Deckker & Murray-Wallace 2021). This is based on our, and other evidence (Barnett 1993, 1994; Fluin 2002; Fluin et al. 2009; Job et al. 2021) that supports the hypothesis that an unchanging sediment transport pathway during the late-Pleistocene-Holocene cannot be assumed for the Murray River due to the formation of the extensive sediment trap from 8.5-5.0 ka that we have posited (Helfensdorfer et al. 2019, 2020). Further, the proposition that the Murray River may have "used a different 'conduit' via the Narrung Narrows, then Lake Albert and finally the Warringee Embayment" to reach the sea at the time of the Murray Gorge infill ignores the location of Monteith. The core Monteith-A site occupies a position located well upstream from both the Murray's exit into Lake Alexandrina at Wellington and the potential entry-point of the Murray River into Lake Albert through the Narrung Narrows (cf. Figure 1). The consequences of sediment trapping at Monteith for the potential delivery of riverine sediment to the ocean would be much the same for any ocean exit point for the Murray River located downstream from Monteith. This alternate 'different conduit' proposal is not relevant to the discussion.

To further substantiate our claims, we present Itrax™ core image and geochemical data (Figures 4 and 5) that demonstrate that the abundant light-coloured mud laminations presented in core Monteith-A were almost certainly derived from the Darling River catchment at a time when there is no trace of Darling River catchment sediment identified in the offshore record (Gingele et al. 2004, 2007). Major elements were analysed down core Monteith-A using an Itrax™ μ-XRF core scanner (ANSTO, Lucas Heights, Australia; 1 mm resolution). Distinctly different chemical compositions for light – and dark-coloured laminae consistent with contrasting source areas (catchments) are indicated by the contrasting deflections of the Zr/Rb and Rb/Sr ratios in Figure 4. Relatively strong leftward-deflections of the scanning-XRF profiles indicate relatively higher Zr/Rb ratios and relatively lower Rb/Sr ratios for light coloured laminae whereas rightward deflection of the profile indicate relatively lower Zr/Rb ratios and relatively higher Rb/Sr ratios for dark laminae. The core was scanned immediately after splitting to minimise oxidative changes prior to analysis.

The core section presented in Figure 4 **is typical** of the upper 12 metres of core Monteith-A which spans the period between 8.5 ka and 5 ka (cf. Helfensdorfer 2020). A cross-valley transect comprised of ten Cone Penetrometer soundings spanning the entire width of the Lower Murray Gorge at the core Monteith-A site was also conducted for the Helfensdorfer et al. (2020) study. These data demonstrate that the stratigraphy presented in core Monteith-A is replicated across the full width of the valley at the Monteith site and that the 20 m thick layer of the so-called Mannum Mud is an uninterrupted, valley-wide deposit (Figure 6).

The section of core Monteith-A shown in Figure 4 (3.40 m to 4.39 m depth) presents sets of delicately interlayered, 0.5 mm to 10 mm thick, distinct light – and dark-coloured, fine-grained laminations of mud and clay that were deposited as a continuous sequence between ~7,150 ka and ~6,900 ka (cf. Helfensdorfer et al. 2020) at a relatively rapid rate of approximately 4 mm per year. The sediments of this core section are typical of the material deposited in unit 5. The combination of the fine grainsize of this material and the delicately interspersed and anastomosing nature of the lamination present in the core are typical of sedimentation of muddy sediments in backwater or still-water settings and lakes (c.f., Reininck & Singh 1986; Bridge 1978). The mean grainsize (D_{50}) for this section of the core interval is 8 μm and ranges between clay at 0.5 μm and fine silt at 16 μm (Figure 4 in Helfensdorfer et al. 2020, and unpublished data). We interpret this sequence of material to represent a continuous depositional record, approximately 250 years long, comprised of clay and mud laminae derived from the entire Murray-Darling catchment that was captured in a still-water environment.

The Itrax™ scan data presented in Figure 5 demonstrates two distinct geochemical signals corresponding to the light – and dark-coloured laminae, respectively (Figure 5). In order to compare these geochemical signals to established signatures of sediment provenance

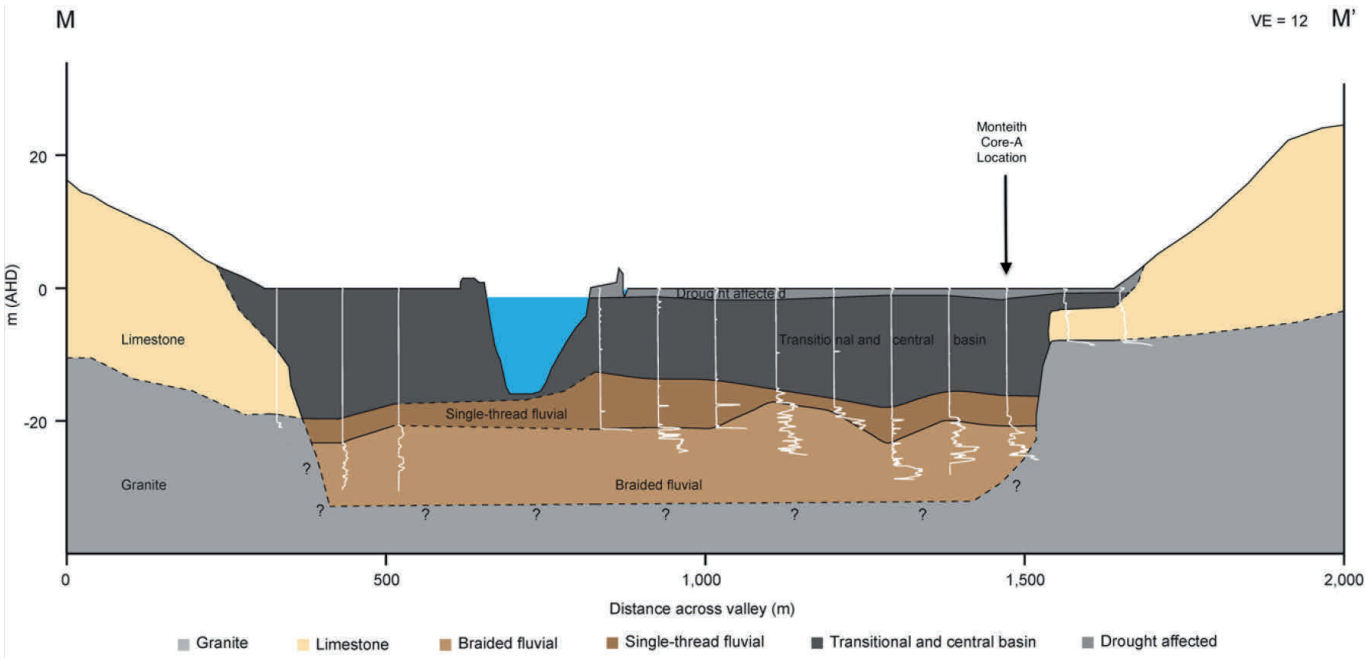

Figure 6: Cross-valley distribution of sediment layers at Monteith identified by Cone Penetrometer (CPT) soundings (white vertical lines). The CPT transect demonstrates the lateral persistence and valley-wide presentation of Monteith's laminated mud unit (see Helfensdorfer et al., 2020 for further detail). Muds of Transitional Unit 4 and Central Basin Unit 5 shown in dark grey, Fluvial Sediments of Units 2 and 3 shown in light and dark brown, respectively. Limestone (cream), granite basement (light grey), and modern (mid-grey) lithologies are also shown (modified from Helfensdorfer et al. 2020).

(Gingele & De Deckker 2005), we determined total element abundances for 13 samples taken from these distinct laminae (6 light (L1, L2, L3, L4, L5, L6), 7 dark (D7, D8, D9, D10, D11, D12 and D13); Figures 4 and 5) and compare these to the Gingele and De Deckker (2005) data for modern-day sediments sampled from the Murray and Darling Rivers. Metals were extracted from a ~0.2 g subsample of dried, finely ground sediment using microwave assisted total digestion (9 mL HNO_3 (70 %) and 3 mL HF (30 %)) in adherence to the EPA 3052 method (USEPA 1996) and measured using inductively coupled plasma mass spectrometry (ICP-MS; Perkin-Elmer NexION 350X). The light-coloured laminations present the distinctive Darling River catchment signature identified by Gingele and De Deckker (2005) with relatively low K_2O, Ba, and Rb content, as well as higher Zr abundance relative to Ti abundance. This contrasts with the geochemical composition of the dark laminations in the core which present the distinctive Murray River signature with relatively higher K_2O, Ba, and Rb abundances in the various plots of Rb, Ba, K_2O, and Zr*100/Ti presented in Figure 5. Note that the field separation is generally more distinct in the Monteith data than the modern-day data.

The general prominence of light-coloured Darling River derived laminations, with more than ten separate >5 mm laminations in this 1 m-long section indicates: (a) that at least ten large Darling River flows occurred during the approximately 250-year long period of record evident in this core segment; and (b) that the Darling River catchment regularly discharged sufficient water and sediment to influence and overwhelm the dominance of Murray River flows at Monteith around 7,000 years ago.

Therefore, statements such as *"Based on examination of the mineralogical and geochemical signals presented by the terrigenous component of deep-sea sediment core MD03-2611 ... there is no mineralogical and isotopic evidence of material from the Darling subcatchment after 13.5 ka. Thus, the predominant rainfall must have occurred in southern Australia, and likely during the winter."* by Gingele et al. (2007) cannot fully represent climatic conditions extant in the Murray-Darling River basin during the mid-Holocene. The data presented in Figures 5 and 6 suggest that conditions quite different to those envisioned by Gingele et al. (2004, 2007) were extant for significant periods of time during the mid-Holocene, justifying our recommendation that interpretations of the hydroclimate record in south-eastern Australia based on the offshore sediment recorded for this period be re-considered.

CONCLUSION

We have presented several arguments that refute the recent criticisms made of our 2019 and 2020 papers in *Scientific Reports* by De Deckker and Murray-Wallace (2021) here and elsewhere (Hubble et al. 2020, 2021). Our core, Monteith-A, presents a progressive transition from fluvial sand sedimentation to transitional, tidally-influenced, sandy-mud deposition at around 9 ka (~ – 15 m AHD), and then to still-water, central-basin mud and clay deposition at around 8.5 ka (-12 m AHD) that continued to 5 ka which is consistent with both: a) the record of local and global sea-level rise over that period; and b) the likely response of the Lower Murray River to the mid-Holocene sea-level highstand that we modelled in our 2019 and 2020 papers.

The finely-laminated light – and dark-coloured muds of the 4.4 m to 3.4 m interval of core Monteith-A presented here are typical of the upper twelve metres of core Monteith-A which was deposited between 8.5 ka and 5 ka. The grainsize of this material and its finely laminated and interlaminated nature are features usually associated with laminites deposited in a still-water or backwater setting. The finer-grained, light-coloured laminations present a geochemical signature typical of the present-day Darling River catchment while the dark-coloured muds present a geochemical signature typical of the present-day Murray River Catchment.

Our evidence indicates that the Darling River was regularly generating substantial flows that were large enough to overwhelm deposition from Murray River flows. This finding conflicts with the conventional views of relatively dry conditions in the Darling River catchment after 13.5 ka (Gingele et al. 2004, 2007; Moros et al. 2009) such that Murray-Daring catchment flows were dominantly derived from south-eastern region of the Murray River catchment. Hence, we have shown that our recommendation that interpretations of the hydroclimate record in south-eastern Australia for this period be reconsidered is a valid and appropriate suggestion.

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THESIS ABSTRACT

DETERMINING THE AGE OF THE EASTERN GREY KANGAROO BASED ON THEIR MANDIBULAR FEATURES AND MEASUREMENTS

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The Lancefield megafaunal site is a swamp deposit comprised of over 10,000 fossilised bones, about 90% of which are from an extinct sub-species of kangaroo (*Macropus giganteus titan*).

These bones have been estimated to be between 40,000 and 60,000 years of age. If the age in years of these kangaroos at death can be determined, this information may be able to help ascertain if the death assemblage is the result of natural attrition or a catastrophic event.

This study aims to develop a new method for assessing the age of eastern grey kangaroos (*Macropus giganteus*) based on their mandibles, which can later be applied to the Lancefield megafaunal site. Three methodologies were followed to determine if an estimation of the eastern grey kangaroo's age could be established.

Kirkpatrick's method of molar indexing was modified and applied on the mandible, and follow-up measurements were taken measuring the distance of the final molar past the established reference point. A logarithmic regression analysis determined that mandibular molar indexing could determine the age of the eastern grey kangaroo until age 5.5 years. For every subsequent year, the linear regression analysis revealed that the posterior molar will move a further 1.61 mm past the reference point.

The diastema length was measured on all mandibles. The linear regression showed no significant relationship with age, and thus this was not an appropriate method of determining the age of the eastern grey kangaroo. Measurements for mandibular body height, body length, body robustness (length x height), ramus breadth, ramus height, ramus robustness (height x breadth) and angle were measured with digital callipers. 2D robustness measurements were also taken as height x width at the apex of the mandibular arch and the posterior of the mental foramen.

The Welsh's t-test found that the body robustness and mandibular arch robustness increased with age, but only in the male populations. As there is no established method of determining gender based on the mandible, this will not be an appropriate method of determining the age of the eastern grey kangaroo.

UPCOMING MEETINGS

Editors COVID-19 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.

DECEMBER 2021

AGU Fall Meeting
Venue: New Orleans, USA
Date: 13-17 December 2021
https://www.agu.org/Fall-Meeting

2022

MARCH 2022

IAL-IPA joint meeting "Lagos, Memorias del Territorio"
Venue: BEC Bariloche Events and Congresses, (Argentina)
Date: 20-24 March 2022
(postponed from March 2021)
www.inqua.org/meetings/list/55

MAY 2022

6th PAGES Open Science Meeting

Venue: Agadir, Morocco
Date: TBC May 2022
http://pastglobalchanges.org/calendar/upcoming/127-pages/2065-pages-osm-2022

AUGUST 2022

19th International Swiss Climate Summer School

Venue: Grindelwald, Switzerland
Date: August 2022.
The PAGES-endorsed 19th International Swiss Climate Summer School on "Extreme weather and climate: from atmospheric processes to impacts on ecosystems and society" has been postponed and will now be held at the end of August 2022. Finalized dates are still to be confirmed. A new call will open in September 2021.
https://pastglobalchanges.org/calendar/20th-swiss-climate-summer-school-2022

SEPTEMBER 2022

European conference on earthquake engineering and seismology

Venue: International Conference Centre, (Romania)
Date: 4-9 September 2022
https://3ecees.ro/

OCTOBER 2022

3rd IPICS Open Science Conference

Venue: Crans-Montana, Switzerland
Date: October 2022

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

Originally scheduled for October 2020 then 10-15 October 2021 in Crans-Montana, Switzerland, postponed until October 2022.
http://pastglobalchanges.org/calendar

NOVEMBER 2022

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

Venue: La Serena y Coquimbo, Chile
Date: 7-11 November 2022.
An initial online session was held in November 2020, and the in-person meeting was rescheduled for 2022.
https://www.pases2020.com

DECEMBER 2022

AQUA Conference (TBC)
Venue: University of Adelaide
Dates: 6-8 December (TBC)
https://aqua.org.au/conference/

2023

XXI INQUA Congress

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

ICAZ (moved to 2023)

Venue: Cairns Convention Center, Australia
Date: 7-12 August 2023
https://www.facebook.com/ICAZ2022cairnsaustralia/

SEMINAR SERIES

Pal(a)eoPERCS (Palaeo Early Career Seminars) Series

Weekly seminars given by ECRs across palaeo – disciplines
https://paleopercs.com

Palynology Short Talks

Monthly seminars hosted by the Palynology Society
https://palynology.org/palynology-short-talks

International Paleofire Network seminar series

Quasi-monthly seminars on paleofire topics hosted by the International Paleofire Network
https://ipn.paleofire.org/?p=1025

Women in Earth and Environmental Sciences in Australia (WOMEESA) Virtual Seminars

Monthly seminars by women in Earth or Environmental Sciences on their research and career pathway
https://www.womeesa.net/seminarseries

RECENT PUBLICATIONS

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