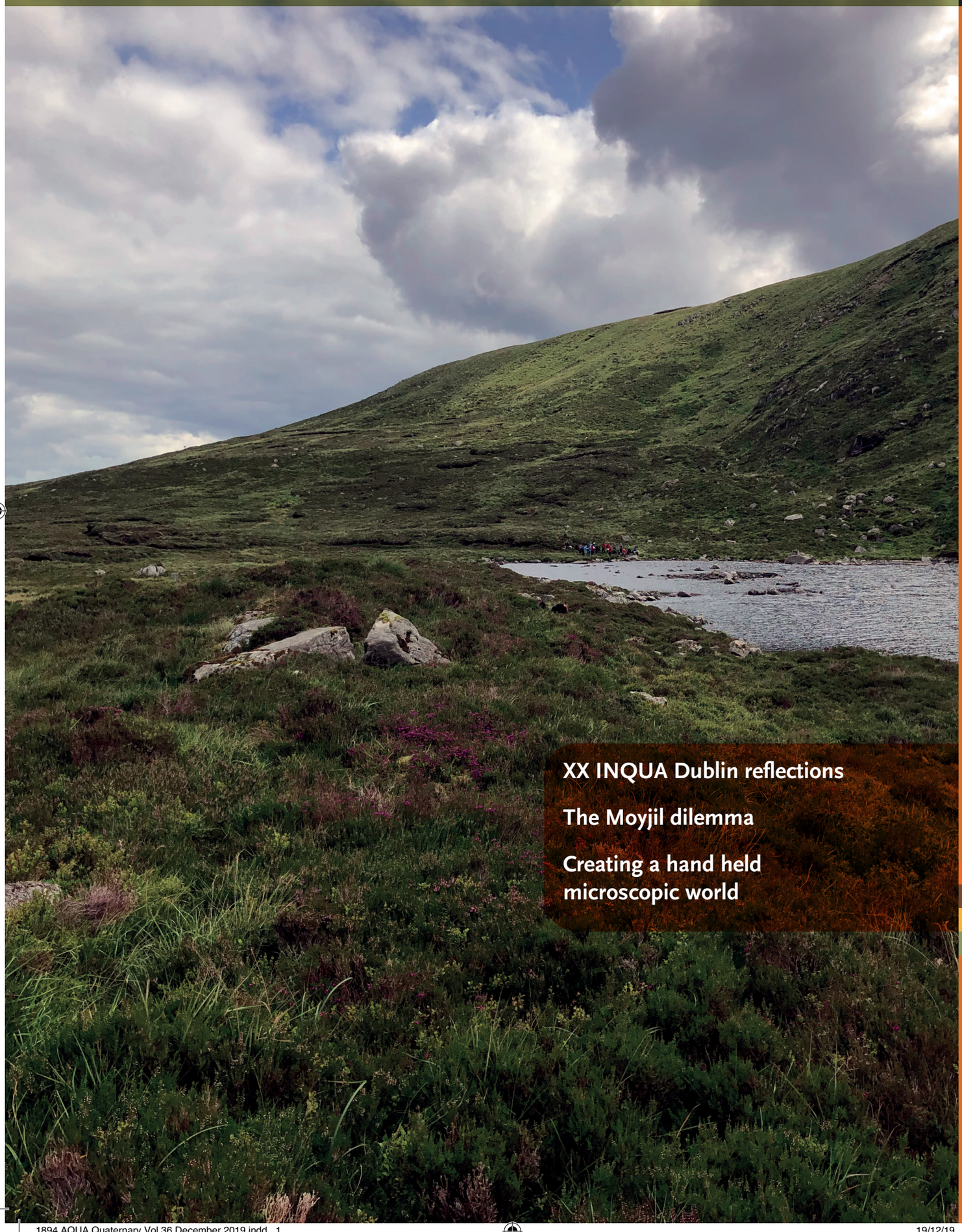
VOLUME 36 | NUMBER 2 | DECEMBER 2019

Quaternary AUSTRALASIA



XX INQUA Dublin reflections

The Moyjil dilemma

Creating a hand held microscopic world

AQUA CONFERENCE 2020

MONDAY 20 JULY - FRIDAY 24 JULY 2020

ATHERTON TABLELANDS, QUEENSLAND

For those who haven't seen the previous announcements, planning is well underway for the AQUA 2020 meeting and a date has been set!

The meeting will be held from Monday 20th to Friday 24th of July, 2020.

On behalf of the organising committee, I am very pleased to announce that the location will be the Atherton Tablelands in far north Queensland. Indeed, the venue for the meeting will be The Atherton Hotel (locally known as the Black Stump) in Atherton itself.

The Atherton Tablelands hold an important place in the history of Quaternary studies in Australasia, and this meeting will be an opportunity to acknowledge these contributions. Of course, it is also a great opportunity to escape the cool southern winters for the warmth of the dry season tropics.

There are numerous accommodation options available in Atherton, however July is peak tourist season, so early bookings are advisable.

The Atherton Hotel have a small number of rooms available and have offered reduced rates for bed and breakfast accommodation for conference attendees. If this is of interest, contact Julie Reedy (07) 4091 7611 at the hotel and state that you are attending the AQUA Conference. Please note, there are very limited numbers of rooms available.

Plans are well underway for social events, a fieldtrip to some of the iconic Tableland locations and, of course, the customary Tim Barrows' quiz night. This is a meeting you won't want to miss. Keep an eye out for AQUAlist notifications and the Facebook AQUA page for further details as they emerge, but for now, block out July 20–24 in your calendar and we look forward to seeing you all in Atherton!

Cheers for now,

The AQUA2020 organising committee

PS: Thanks to Haidee Cadd for the (very apt) meeting logo.

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Quaternary AUSTRALASIA

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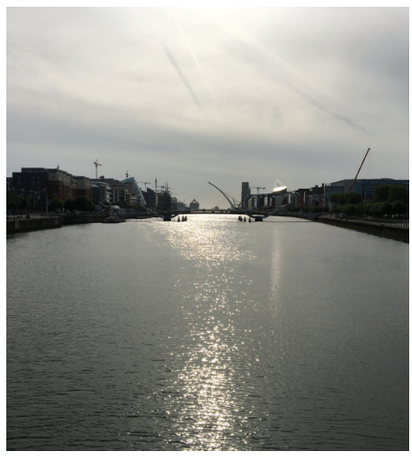
Front cover photo:

Kellys Lough, INQUA field Trip to the Wicklows.
(Photo credit: Tim Barrows)

Below:

The beautiful Boyne river.
(Photo credit: Emma Rehn)



EDITORIAL

Dear Quaternarists,

In this post-INQUA edition, we have many reports from the congress in Dublin. A strong contingent from AQUA were in attendance, representing postgraduates, ECR's, mid and senior academics and partners. We hear from our AQUA travel awardees, Tim Pollard, Valerie Van Den Bos and Emma Rehns who recount their experiences of INQUA from plenary's to field excursions.

INQUA is always a vast smorgasbord of Quaternary science; the opportunity to sample areas outside your own speciality, and also to focus in on your particular research discipline. The opportunity also to talk to the leading researchers in Quaternary science, and to catch up with old friends. AQUA researchers were well represented at the congress: two SHAPE sessions, a SHeMax session and Helen Bostock delivering one of the plenary speeches. Lynda Petherick updates us on the SHeMax session, while Tim Barrows recalls two of the field excursions.

Away from INQUA, we have further articles representing the varied scope of Australasian Quaternary research. David Lowe provides a comprehensive summary of the state of Quaternary Science in New Zealand, while Helen Bostock reports on the 13th International Conference on Paleoceanography. Janelle Stevenson provides a detailed report on the application of 3D printing of microscopic pollens to facilitate effective teaching practice.

Scientific research is often described as "standing on the shoulders of giants"; whereby we discover truth by building on previous discoveries. Rigorous peer review and debate allow us as scientists to test hypotheses and consider the results of research from an objective and mature perspective. In this issue, our feature article from Jim Bowler reflects on the wider implications of research published earlier this year which detailed evidence for the early human occupation (120 ka) of a clifftop site at Warrnambool Victoria. As Jim himself notes in the acknowledgements to his article, ..."Despite a dire warning that "No archaeologist will believe you", the risk of encouraging scandal is more than off-set by the need to challenge disbelief."

Finally, we look forward to the AQUA Conference in 2020. The glorious Atherton Tablelands will be the venue for our next Quaternary gathering, from 20-24 July. The warmth of the dry season tropics awaits: so save the date!

Yours Quaternarily,

Sanja van Huet and Carol Smith
Co Editors

PRESIDENT'S PEN

Dear fellow AQUA members,

Spring has arrived in the Southern Hemisphere and many AQUA folk have returned from the 20th INQUA Congress held in Dublin, Ireland.

AQUA was exceptionally represented, including having Associate Professor Helen Bostock (UQ) present one of the plenary speeches. At the Congress it was decided (and certainly going against the prevailing AQUA vote) that the next INQUA congress would be held in Rome.

Closer to home the AQUA Meeting organising committee have announced the dates and location of the next AQUA meeting; Monday 20th to Friday 24th of July, 2020 in Atherton, far north Queensland. Please keep an eye out for more details as it is likely there will be at least one workshop held prior to the AQUA meeting.

All the best for the summer's field activities.

Tim Cohen
AQUA President

NEWS

ARC GRANT OUTCOMES IN QUATERNARY STUDIES AND ARCHAEOLOGY

Simon Harberle

College of Asia and the Pacific, Australian National University, ACT, Australia

Dear Colleagues,

The Australian Research Council (ARC) season of funding announcements is upon us, somewhat transformed from previous years with embargoes and shifting announcement dates across the nation. Nevertheless, funding is critical for academic careers and research and the ARC has recently announced the Linkage Project grants, Discovery Early Career Researcher Awards and the Future Fellowship grants. Below are the successful grants in the broad fields of Quaternary Studies and Archaeology.

Congratulations to all those who have been successful.

DECRA

THE AUSTRALIAN NATIONAL UNIVERSITY

DR STUART HAWKINS (DE200100133)

Early animal husbandry and socio-political complexity in the Asia-Pacific.

This project will investigate the origins of animal husbandry and its link to the creation of wealth, the development of socio-political prestige systems, the rise of inequality, and the coevolutionary effects of the domestication process on pigs. It focuses on 15 stratified Neolithic archaeological sites in the tropical island region of Island Southeast Asia and the Pacific dating between 4000-500 years ago. An expected outcome will be the establishment of an integrated evolutionary theoretical model that could be applied to analyzing agricultural transitions globally. Such a model predicts socio-political and rational economic strategies in pig management systems and can be tested using zooarchaeological analyses. Funding: $409,297.00
The University of New South Wales
Dr Zoë Thomas (DE200100907)
Investigating the synchroneity of global atmospheric shifts in the Holocene.

The austral mid-latitude westerly winds dominate Southern Hemisphere climate variability today (including the Australasian region) and are tightly coupled to the Southern Ocean, modulating the air-sea CO_2 flux. However, short instrumental records in the south make future climate projections uncertain. This Project will develop the first highly-detailed reconstructions of westerly airflow from targeted Southern Ocean islands during key periods of change, representing a range of climate states over the Holocene (the last 11,650 yrs). Intensive radiocarbon dating will allow precise alignment to a network of palaeoclimate records to test the timing, drivers and impacts of circulation change across Australia and globally.

Funding: $426,715.00

UNIVERSITY OF WOLLONGONG

DR SAM LIN (DE200100502)

The hobbit's tools and the evolution of human behaviour in Southeast Asia.

This project aims to investigate the behavioural evolution of the extinct Homo floresiensis (the 'hobbit') and modern humans on Flores, Indonesia. Using innovative, interdisciplinary approaches to integrate stone tools with simulation modelling, this project expects to generate new understanding about the behavioural strategies of the two human species and their interactions with the Flores environment over the past 190,000 years. Anticipated outcomes include refined knowledge of human evolution and interaction in island Southeast Asia, and innovative experimental methods for the study of stone tools. This will emphasise Australia's role in international human evolution research, and inform the study of comparable stone tools in Australia.

Funding: $427,116.00

THE UNIVERSITY OF MELBOURNE

DR AMY PRENDERGAST (DE200100890)

Rapid climate change, early modern human dispersal, and Neanderthal demise.

Why are we the only surviving human species? This project aims to investigate whether seasonal environmental changes associated with rapid climate change events played a role in the expansion of our own species and the demise of Neanderthals between 60,000-30,000 years ago. The project will generate quantitative, sub-seasonal records of past climate variability using novel multi-proxy analyses from key archaeological sites, offering a framework for understanding early human responses to extreme climate fluctuations. This may inform our strategies for coping with future extreme scenarios. These unparalleled records will also provide data to test and refine climate models, enabling a better understanding of Earth's climate system.

Funding: $427,082.00

MONASH UNIVERSITY

DR ROBERT SKELLY (DE200100544)

Reconnecting the Histories of Papuan, Australian and Oceanic Seascapes.

This project aims to investigate connections between Papuan, Australian and Oceanic seascapes created by a westward expansion by Lapita seafarers 3000 years ago. The project raises and addresses new questions about the maintenance of regional social relationships with an innovative archaeological approach that focuses on the edges of cultural domains where people met and shared ideas. Expected outcomes include enhanced research collaborations and improved regulatory capacity. Reconnecting seascapes is expected to inform and benefit academic and government responses to heritage conservation and align with Australian Government aspirations to conserve regional cultural heritage and enable economic development through strategic collaboration.

Funding: $418,810.00

THE UNIVERSITY OF WESTERN AUSTRALIA

DR EMILIE DOTTE-SAROUT (DE200100597)

Pacific Matildas: Finding the women in the history of Pacific archaeology.

This project aims to investigate the scientific lives and contributions of women in the development of a particular discipline; using Pacific archaeology as a case study. The history of science has traditionally produced gender biased narratives, so an innovative interdisciplinary approach will be developed to document the hidden role of women in the history of archaeology. New knowledge will be generated in the history of science, archaeology and gender studies. Anticipated outcomes include (i) a more inclusive history that provides diverse role models of women in science from our region, (ii) the identification of socio-cultural patterns limiting women's careers and successful strategies historically developed to overcome these.

Funding: $399,551.00

LINKAGE PROJECTS

THE UNIVERSITY OF NOTRE DAME AUSTRALIA

DR LYNLEY WALLIS; ASSOCIATE PROFESSOR HEATHER BURKE; DR JILLIAN HUNTLEY; DR JONATHAN OSBORN; PROFESSOR BRYCE BARKER; PROFESSOR MAXIME AUBERT; DR DARYL WESLEY; DR TRISTEN JONES; PROFESSOR NIGEL SPOONER; DR NOELENE COLE (LP190100194)

Aboriginal rock art and cultural heritage management in Cape York Peninsula.

The Laura Sandstone Basin of Cape York Peninsula hosts one of the richest bodies of rock art in Australia and the world. It documents the life-ways of generations of Aboriginal Australians from their original settlement, through major environmental changes, to European invasion. This vast area, much of which is now jointly managed as National Parks by Traditional Owners, remains virtually unexplored archaeologically. This project aims to record this unique rock art so that its testimony remains for future generations. This will provide a framework for its sustainable management and findings will have profound implications for our understandings of the cultural behaviour and dispersal of the earliest modern humans to colonise Australia. Balnggarrawarra Aboriginal Corporation; South Cape York Catchments Inc.; Buubu Gujin Aboriginal Corporation; Cape Melville Flinders & Howick Islands Aboriginal Corporation; Department of Environment and Science; South Cape York Catchments Inc.- Laura Indigenous Land And Sea Rangers; Wallis Heritage Consulting; Waarnthuurr-Iin Aboriginal Corporation.

Funding: $1,342,000.00

Above: AQUA/INQUA travel awardees at the INQUA congress, 2019.

L to R: Valerie van den Bos, Tim Pollard, Ellen Corrick pose in front of the Tusks at the Dublin Convention Centre.

Left: Tim Barrows and Stephanie Mills would like to announce that Emilie Ellen Barrows was born 16:01 on 18th October weighing 3.01 kg. Both mum and baby are doing well.

CAPTION COMPETITION

Patricia Gadd submitted this photo of Craig Sloss at INQUA for the Caption Competition.

Let us know what Slossy is thinking ...

INQUA POST CONGRESS FIELD TRIP: THE GLACIATION OF THE MOURNE MOUNTAINS

Tim Barrows

University of Portsmouth, UK and University of Wollongong, NSW, Australia

The Mourne Mountains represent an iconic glaciated landscape in Northern Ireland. The highest peaks of the Mournes, topped by Slieve Donard (853 m), are dissected by visually dramatic over-deepened U-shaped valleys and skirted by rogen moraines and rolling drumlins (Roberson, 2019). The Mourne Mountains were extensively glaciated during the last glacial cycle, evidenced by a glacially eroded valley, dispersed erratics, moraines and widespread till and outwash deposits (Roberson, 2019). The geology and geomorphology of the Mournes and the adjacent lowlands area are fundamental to understanding the evolution and dynamics of the Irish Sea Ice Stream, the main outlet glacier of the British and Irish Ice Sheet (Roberson, 2019).

On Day 1, we got a rare glimpse inside a drumlin that was sectioned in an old quarry. This is one of hundreds of drumlins on the plain to the north of the Mournes, where the Irish Ice Sheet skirted to the east. At more than half a kilometre long, it includes deformed lacustrine sediments and channel sediments. There is evidence of glaciotectonic deformation across a range of scales.

We then visited the Killard Point moraine to the northeast of the Mourne Mountains. The sequence at Killard Point is central to understanding deglacial conditions in the northern part of the Irish Sea. The sequence is composed of three main lithofacies, lower gravelly diamict, a middle sand and upper gravel. These sediments mark the retreat of ice in the Irish Sea after 17 ka in a glaciomarine setting.

On Day 2, we visited the Annalong Valley in the Mourne Mountains. The Annalong Valley is a ~6 km long glacial trough extending out onto the Mourne Plain and preserves one of the best glacial sequences in the Mournes. The sequence is comprised of several arcuate moraines and associated outwash terraces. The general view is that these moraines reflect ice extent during the Killard Point Stadial (~17.2–16.6 cal ka BP). New exposure ages from Eric Colhoun will help constrain the timing of glacier retreat. Following the retreat of valley glaciers from the Annalong Valley, the final phase of ice advance probably occurred during the Younger Dryas chronozone in the form of cirque glaciers.

On Day 3 we visited coastal sections at Kilkeel. The occurrence of shelly 'Irish Sea Till' along the coast of eastern Ireland, Wales and north-western England has long been recognised as the result of large-scale glaciation of the Irish Sea Basin. On the Mourne Plain 'Irish Sea Drift' contains a characteristic suite of erratics, including shell fragments, flint and microgranite from the island of Ailsa Craig, off the south-western coast of the Southern Uplands of Scotland. The retreat of the main Irish Sea Ice Stream to the north of the Mourne Plain after LGM is thought to have been followed by three major readvances, punctuated by periods of relatively mild conditions (Roberson, 2019). The lithostratigraphy for the Pleistocene deposits underlying the Mourne Plain consists of six units representing the advance, readvance and retreat of ice in the Irish Sea.

We thank Lauren Knight, Sam Roberson, Mark Cooper and Jon Merritt for outstanding field trips and excellent field guides.

REFERENCES

Colhoun, E.A., Synge, F.M., (1980). The cirque moraines at Lough Nahanagan, County Wicklow, Ireland. *Proceedings of the Royal Irish Academy* 80B:25-45.

Knight, L., Boston, C., Lovell, H., Pepin, N., (2019). Younger Dryas glaciation in the Wicklow Mountains. *Field Guide for the XXth INQUA Congress, Dublin*. Irish Quaternary Association, Ireland.

Roberson, S., (editor) (2019). The Glaciation of the Mourne Mountains. *Field guide for the XXth INQUA Congress, Dublin*. Irish Quaternary Association, Ireland.

Previous Page - Figure 1: Killard Point glaciomarine sequence. Photo credit: Tim Barrows.

Top: Figure 2: Annalong Valley Moraine. Photo credit: Tim Barrows.

Above Left to Right - Figure 3: Emeritus Professor Eric Colhoun points out features in the Annalong Valley. Photo credit: Tim Barrows.

Figure 4: Boulder weathering in the Annalong Valley. Photo credit: Tim Barrows.

Figure 5: Granite erratics in till, coastal section at Kilkeel. Photo credit: Tim Barrows.

Below: Figure 6: Mourne Mountains field trip participants Photo credit: Tim Barrows.

INQUA MID CONGRESS FIELD TRIP: YOUNGER DRYAS GLACIATION IN THE WICKLOW MOUNTAINS

Tim Barrows

University of Portsmouth, UK and University of Wollongong, NSW, Australia

The mid-congress field trip was an introduction into the extent and style of Younger Dryas glaciation in the Wicklow Mountains. The Wicklow Mountains form the largest expanse of continuous upland in Ireland and are therefore a key area for understanding the extent and style of Younger Dryas glaciation in the region (Knight et al. 2019). In Ireland, the Younger Dryas chronozone is referred to as the Nahanagan Stadial (Colhoun and Synge, 1980). Lauren Knight and colleagues have remapped the cirques and moraines through the Wicklow Mountains to reassess the extent of glaciation during the Younger Dryas Stadial. We visited the sites most likely to host cirque glaciers based on detailed geomorphological mapping, morphostratigraphy and solar radiation modelling.

Site 1 was Lough Nahanagan, which is the Irish Younger Dryas type site. Colhoun and Synge (1980) described moraines at the cirque and radiocarbon dated the sediments (Eric Colhoun subsequently emigrated to Australia and worked extensively on Tasmanian glaciation).

Site 2 was Kelly's Lough, which has some of the most spectacular Younger Dryas moraines in the Wicklow Mountains. Access was via a steep glacial trough wall, flattening out onto a shelf. Emeritus Professor Martin Williams, whose first scientific paper was on Irish glaciation (Williams, 1964), made it to the top.

Site 3 was the Brays, where there are two cirque lakes, Lough Bray Upper and Lough Bray Lower. It remains unclear here whether Nahanagan Stadial ice was confined to the upper lake only. New exposure ages from Eric Colhoun support a limited ice model, with lower moraines dating earlier to the deglaciation.

We thank Lauren Knight, Sam Roberson, Mark Cooper and Jon Merritt for outstanding field trips and excellent field guides.

Left - Figure 1: Lough Nahanagan in the Wicklow Mountains. Photo credit: Tim Barrows

Below - Figure 2: Kellys Lough in the Wicklow Mountains. Photo credit: Tim Barrows

Figure 3: Wicklow Mountains field trip participants.
Photo credit: Tim Barrows

REFERENCES

Colhoun, E.A., Synge, F.M., (1980). The cirque moraines at Lough Nahanagan, County Wicklow, Ireland. *Proceedings of the Royal Irish Academy*, 80B: 25-45.

Knight, L., Boston, C., Lovell, H., Pepin, N., (2019). Younger Dryas glaciation in the Wicklow Mountains. *Field guide for the XXth INQUA Congress, Dublin*. Irish Quaternary Association, Ireland.

Roberson, S., (editor) (2019). The Glaciation of the Mourne Mountains. *Field guide for the XXth INQUA Congress, Dublin*. Irish Quaternary Association, Ireland.

Williams, M.A.J., (1964). Glacial breaches and sub-glacial channels in south-western Ireland. *Irish Geography*. 5:83-95.

AQUA @ INQUA

Group photo at INQUA, Ireland, 2019. Photo credit: Tim Barrows

SELECTED HIGHLIGHTS FROM PLENARIES AND OTHER INVITED SESSIONS AT INQUA CONGRESS 2019

Tim Pollard, PhD candidate

The School of Geography, University of Melbourne, Vic, Australia

The INQUA Congress 2019 featured a number of excellent plenaries and other invited talks. Eric Wolff, former aspiring industrial chemist at Kodak, now world-renowned ice core palaeoclimatologist, opened up proceedings with an update on recent advances in polar ice core science. Eric spoke about the need to improve ice core chronologies so that we can better understand the sequence of changes occurring through climatically important intervals of the Quaternary. He touched on studies linking polar ice core records to other radiometrically dated archives from across the globe, including recent work using U/Th dated speleothem records to assess the global synchrony of millennial-scale climate oscillations linked to DO events in Greenland. Eric also gave an update on efforts to extend the Antarctic ice core record beyond its present 800,000 year limit under the EU supported BE-OI (Beyond EPICA – Oldest Ice) project, as well as current work to retrieve an ice core record from the potentially vulnerable West Antarctic Ice Sheet extending back to the Last Interglacial. Both of these campaigns tie into Eric's broader aim of improving our understanding of past interglacial climates to a point where we can definitively say how much different parts of Antarctica and Greenland contributed to observed sea level rise during past warmer-than-present interglacials. Eric also discussed recent advances in the development of ice core noble gas proxies, which in ideal materials, have the potential to provide reliable estimates of global mean ocean palaeotemperatures.

AQUA's own Helen Bostock gave an excellent plenary, which featured analogies of Champagne bubbles and some Champagne science. Helen discussed some of the mechanisms responsible for large-scale atmospheric CO_2 variations throughout past glacial-interglacial cycles. The talk focussed largely on how atmospheric CO_2 drawdown from the last interglacial to the LGM was accomplished mostly through three main mechanisms, operating largely throughout the Southern Ocean: Antarctic sea-ice expansion, deep ocean circulation changes, and Fe fertilisation of biological productivity. Interestingly, she described how proxy records provide good evidence that these mechanisms operated in a quasi-sequential fashion and dominated at different times throughout the last glacial, with sea ice expansion and attendant 'barrier' effects most significant during the first large drop at ~115-100 ka, deep ocean circulation changes and later Fe fertilisation (especially of the Subantarctic ocean) being most important during the second major drop at ~72–65 ka, and a combination of factors being implicated in the final CO_2 dip toward the LGM minimum.

Quaternary climate modelling guru Qiuzhen Yin, of the famous Université Catholique de Louvain palaeoclimate modelling group, gave an excellent overview of her work modelling past interglacial climates during her 2019 Shackleton Award acceptance talk. Qiuzhen explained how insolation and CO_2 forcing have worked in combination to deliver interglacial climates of varying length and intensity over the past 800,000 years. She described how according to her modelling experiments certain interglacials, such as MIS 5e (~130–115 ka) and 9e (~335–325 ka), were globally warm due to both strong insolation and strong CO_2 forcing, whereas 11c (~425–395) was a warm interglacial only due to its strong CO_2 forcing. It remains to be explained precisely why CO_2 was so high at this time. Other interesting take home messages for an AQUA audience were that past *intra*-interglacial temperature variations in the Southern Hemisphere are mostly attributed to differences in CO_2 forcing, whereas variations in precession are much more important in the NH (and indeed in explaining differences in monsoon intensity). Also, the insolation component of past interglacial warmth in the high southern latitudes is thought to be correlated strongly with obliquity – even more so than in the high northern latitudes.

INQUA MID-CONFERENCE FIELD TRIP: BRÚ NA BÓINNE AND THE HILL OF TARA

Valerie van den Bos

School of Geography, Environment & Earth Sciences, Victoria University of Wellington, New Zealand

Palaeoanthropologist Yohannes Haile-Selassie gave a commanding plenary on his work adding branches to the hominin family tree in the Afar region of Ethiopia. The Afar region is well-known for its namesake *Australopithecus afarensis* (the partial skeleton 'Lucy' being the most famous fossil example of this species), however, it has also yielded a wealth of information on other Australopithecine species. Yohannes' career has largely focussed on combing the Middle Awash site for hominin fossils. He spoke about some of his group's most exciting finds there, including a 3.4 million year old partial hominin foot with an opposing big toe that is thought to belong to a more primitive species contemporaneous with *A. afarensis*. He also discussed the discovery of fossil jawbones that have been attributed to a new species (probably descendant of *A. afarensis*) named *Australopithecus deyiremeda*. For someone like me who is relatively uninitiated in palaeoanthropology, the take home message from this talk seemed to be that the more we discover about hominin evolution, the more complicated (and less tree-like) things seem to get.

Last July I was able to attend my first INQUA, not least thanks to the travel award granted to me by the AQUA community. After the first three days of talks, workshops, meeting people from all over the world, and fighting for the best lunch option, the mid-conference break was very necessary and welcome. I spent the break on one of the organised field trips, namely to Brú na Bóinne and the Hill of Tara, led by Dr. Stephen Davis.

The first leg of the trip took us ~40 km north of Dublin. Brú na Bóinne means "Palace of the River Boyne" and is the location of three large Neolithic passage tombs of which we visited two: Newgrange and Knowth. Passage tombs are large mounds containing one or more burial chambers and covered with large stones and earth. All three sites at Brú na Bóinne are aligned with astronomical significance: Knowth is oriented towards the spring and autumn Equinox and Newgrange towards the rising sun of the winter solstice. Knowth is the largest mound covering about a hectare and contains a large assemblage of megalithic art, which was mysterious and beautiful. However, it was Newgrange which left a lasting impression.

The appearance of Newgrange is striking, as the mound is walled by white quartz cobblestones and large engraved kerbstones. Around the mound stands a ring of large granite stones. The tomb was built around 3300 BC, before the pyramids. Some of the rock comes from the Wicklow Mountains, ~70 km south of the site, and some from the Mourne Mountains, ~60 km southeast. Stephen explained that it would have taken several generations to assemble the mound. I marvelled at the motivation and determination of these people, a farming community, while I can hardly make time to prepare my own presentation at INQUA. Newgrange was even more impressive on the inside. We were allowed to crawl our way through a narrow and low corridor to the inner chamber. A claustrophobic space so mystical we hardly dared to talk in whispers. Once there, our hosts emulated the sunrise on the winter solstice for us, creeping slowly through the passage. In the low light we were able to see the art and inscriptions left by the Neolithic people on some of the stones. The longer you looked, the more you saw.

After this humbling experience at Brú na Bóinne we wound our way to the Hill of Tara, ~20 km northwest of Dublin. The hill is said to have been the ancient seat of kings and features in Irish religion and mythology as the dwelling of the gods and entrance to the otherworld. Later, Saint Patrick would have come to the Hill of Tara to confront the religion of the pagans. Here was less to see than at Brú na Bóinne: Small mounds and scars in the landscape where there would have been large buildings in the past. Nonetheless we spent a pleasant afternoon strolling in the sun (the weather was lovely) while listening to tales of ancient kings and queens and fairies.

Before long, it was time to head back to the convention centre in Dublin; our energy replenished and spirits invigorated, ready to take on the second half of the conference.

MID INQUA CONGRESS FIELDTRIP REPORT: BRÚ NA BÓINNE AND THE HILL OF TARA

Emma Rehn, PhD candidate

College of Science and Engineering, James Cook University, QLD, Australia

After three intense days of INQUA congress proceedings, fieldtrip Sunday was a very welcome break to visit the outdoors. We had beautiful weather for our visit to two passage tombs of the UNESCO World Heritage listed Boyne Valley complex and the earthen structures of the Hill of Tara, led by Dr Stephen Davis of the University College Dublin.

NEWGRANGE

After crossing the Boyne River by bridge, the first stop was the well-known Newgrange. The Newgrange passage tomb still retains an impressive outlook over the Boyne Valley, and has remained watertight for approximately five thousand years since its construction around ~3200 BC.

Photography is currently banned within the tomb itself. Small groups are led by a guide through the entrance, ducking under low rock lintels and squeezing through narrow sections of the path between the upright stones lining the walls. The passage reaches about one third of the way into the mound (~19 metres), ending in a central circular chamber, with three smaller chambers branching off to create a cruciform shape. Looking up, a beautiful corbelled ceiling of overlapping stones stretches over three metres above. Smooth stone basins rest in the centre of each of the smaller chambers, with rock art including radiating circles, engraved diamonds and triple spirals decorating the walls and ceilings.

When walking into the tomb, you hardly notice the approximately two metre increase in elevation along the passage that aligns the central chamber with the "roofbox" above the entrance. The Newgrange Winter Solstice Lottery allows a lucky few to see less than twenty minutes of sunrise within the tomb on the (northern hemisphere) winter solstice. As we can't all win the Newgrange Lottery, artificial lighting lets visitors experience a facsimile of the sunrise alignment with the roofbox – as well as what true darkness looks like before the light is switched on. No smoke residue has been found on the corbelled stone ceiling, indicating that visitors to the tomb prior to electric lighting did not see their way by firelight, potentially only entering Newgrange when lit on the solstice. 18th and 19th century graffiti within Newgrange is both historical archaeology and a testament to the human desire to leave our mark in often destructive ways.

All Photo credits: Emma Rehn

Left - Right:

Newgrange Selfie: Me at the entrance to Newgrange.

Newgrange 67: Newgrange Kerbstone 67.

Newgrange Mound: Newgrange mound, looking southeast.

KNOWTH

Intricately decorated kerbstones ring the main (grand) mound at Knowth, a short bus ride away from Newgrange.

Unlike Newgrange, not one but two separate passages extend through the main mound at Knowth, including the longest megalithic passage in Europe (the eastern passage, ~40 metres length).

Additionally, multiple smaller mounds surround the main mound at Knowth. Visitors are able to descend into one large room within the eastern side of the main mound to experience a virtual reality tour of the internal passages, and see the historic trench that cuts into the side of the main mound. When entering and exiting this room, you are able to look down the long eastern passage protected by a metal gate.

Steps also lead up the exterior of the main mound to a boardwalk providing panoramic views of the surrounding countryside. Many of the delegates (myself included, let's be honest) were captivated when entering and leaving Knowth with the litter of stray kittens currently living around the site, two of which slowed our departure by hiding under the bus.

Left - Right:

Knowth Main: Knowth Main Mound (centre).

Knowth Stones: Knowth Main Mound near western passage showing Kerbstones 76 (left foreground) to 70 (centre distance).

Knowth 57: Knowth Main Mound Kerbstone 57.

Knowth Passage: View down the eastern passage of the Main Mound, Knowth.

Knowth Mounds: Mounds at Knowth.

THE HILL OF TARA

After lunch, our visit to the Hill of Tara, the famous seat of the High Kings of Ireland, was guided by Treasa Kerrigan (of Sacred Sites of Ireland, http://www.sacredsites.ie). Treasa told us a selection of the many stories surrounding the earthwork features at Tara, including how the Mound of the Hostages may have gotten its name and tales of the life and elopement of Gráinne (for whom the feature Rath Gráinne, or Gráinne's Enclosure, is named) with various possible endings. As at Newgrange and Knowth (and many other archaeological sites across Ireland), great views can be had from standing atop Rath Gráinne. While a casual observer would notice that the grassy mounds and ditches that make up the Hill of Tara were unlikely to have formed naturally, Treasa's storytelling provided otherwise unseen layers of meaning to this cultural landscape.

This was a highly informative and enjoyable fieldtrip, as well as a great day out. Many thanks to Dr Stephen Davis for organising the trip and sharing his archaeological expertise, and to Treasa Kerrigan for guiding us through Tara.

Above: Tara Hostages: Mound of the Hostages, Hill of Tara.

Below: Tara Grainne: Standing atop Rath Gráinne looking west, Hill of Tara.

QUATERNARY SCIENCE IN NEW ZEALAND: REPORT TO THE CATALYST FUND

David J. Lowe

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Editor's note: the following report, (including Appendix A) was prepared by David Lowe for the New Zealand Royal Society (Te Apārangi) Catalyst Fund. It is an annual report on behalf of the Quaternary research community in New Zealand with regard to international membership of the International Union for Quaternary Research (INQUA) to the Royal Society (Te Apārangi) Catalyst Fund.

David Lowe writes: "*I have discussed the report with some of the leading New Zealand Quaternarists and/or leaders of several INQUA-funded projects/IFGs (names are listed below)*".

SUPPORTED INTERNATIONAL UNION MEMBERSHIP:	INTERNATIONAL UNION FOR QUATERNARY RESEARCH (INQUA)
New Zealand national delegate:	**Professor David J. Lowe**
Affiliated New Zealand organization/national committee:	Group of New Zealand Quaternary researchers, most of whom are members of the **Australasian Quaternary Association (AQUA)**, which is affiliated with INQUA, and various other science associations/societies in New Zealand.
President/Chair of New Zealand organisation or national committee (or Secretary if the President is the same as the NZ National Delegate):	**Dr Lynda Petherick** (Victoria University of Wellington) is current Vice-President of AQUA (2018-2020). **Dr Helen Bostock** (NIWA) is Immediate Past-President, AQUA, and member ex officio of AQUA Committee (2012-18).
Reporting year:	**2018**
Report date:	**5 December 2018**

Citation: Lowe, D.J. 2018. Quaternary research in New Zealand and relationship to the International Union for Quaternary Research (INQUA). *Annual Report for 'Catalyst Fund: Influence' for 2018*. School of Science, University of Waikato, Hamilton, 7 pp.

1. CATALYST: INFLUENCE ASSESSMENT CRITERIA

1.1. *Please comment on how the supported union membership involves recognised global science and innovation leaders, the connection with whom could benefit New Zealand in a substantive manner.*

Many of the top Quaternary science specialists globally are members of the International Union for Quaternary Research (INQUA), and a number of New Zealand Quaternary scientists are in that category. Membership of INQUA provides access to this international knowledge base and the latest developments in the discipline, as described in the report for 2017, which included Appendix A (report completed in March 2018: Lowe, 2018a). The appendix provided examples of the international recognition of New Zealand Quaternary researchers and geological archives as globally important or unique, and of New Zealand participation and leadership in (a) globally-significant research and (b) in decision making at the international level through INQUA and through associated activities/outlets involving Quaternary research and its dissemination.

Most of New Zealand's Quaternary researchers have been involved with INQUA-led projects or research groups, referred to as international focus groups (IFGs), that enable them to tackle globally-relevant research questions in the disciplines encompassed by the Quaternary (see Appendix A of Lowe, 2018a). Key questions about climate change in the past are a main focus because understanding the causes and timing spatially and through time requires a global and multi-disciplinary approach, with a Southern Hemisphere perspective especially important because of the general paucity of data in much of the hemisphere to compare with that from the Northern Hemisphere. Future models of changing climate are largely contingent upon robust paleoenvironmental data, dated at high precision, being obtained from a range of archives throughout New Zealand and surrounding marine sediments by Quaternary scientists (IPCC, 2018). Increasingly, high-

resolution past-environmental data are needed as are improved chronologies, to enable questions of leads and lags in past climate systems to be answered at a range of scales (both regionally and globally).

INQUA's five broad commissions (Coastal and Marine Processes; Humans and the Biosphere; Palaeoclimates; Stratigraphy and Chronology; Terrestrial Processes, Deposits and History) provide seed funding to IFGs and projects annually (on a competitive basis) to enable new and especially collaborative research to be undertaken on important topics that may incorporate revised or new methodologies. Many early career researchers (ECRs) especially have benefitted from the funding provided by INQUA through support to attend and participate in meetings and conferences through travel grants. In addition, the New Zealand and Australian Quaternary research communities have forged closer relationships over the past decade under the umbrella of the Australasian Quaternary Association (AQUA), which is affiliated with INQUA. AQUA members have been very active with biennial conferences hosted in New Zealand and Australia, the publication of biannual newsletters, and financial and in-kind support for the INQUA-led IFGs and projects.

1.2. *Please comment on how the International Union membership has advanced New Zealand's research, science and technology reputation over the last year and/or presented new opportunities for collaboration in research fields of strategic importance to New Zealand.*

From 1 January to 31 December 2018, the New Zealand Quaternary research community, with strong support from Australian counterparts, made significant advances in several ways, in part catalyzed through membership of INQUA:

(a) By continuing and maintaining collaborative national and international opportunities for presenting and discussing new research and networking at five conferences/workshops held in this period by leaders of INQUA-funded IFGs and project – the key IFGs and projects in New Zealand currently supported by INQUA include SHAPE (ongoing IFG), INTAV (ongoing IFG), EXTRAS (project), SHeMax (project), and AQUA itself (biennial conference);

(b) by supporting and mentoring ECRs (including students) through the GNS Science Quaternary Techniques Short Course;

(c) by mentoring and developing ECRs (including students) through provision of opportunity for them to participate in conferences or workshops using funds provided by INQUA and AQUA to support travel or to offset registration or other costs; and

(d) by contributing to the formal subdivision of the Holocene in a publication this year (Walker et al., 2018).

The development of several key IFGs and projects, led in part by New Zealand Quaternary researchers, has been critical in improving and bringing together researchers with widely varying interests to tackle difficult problems and 'big' topics such as climate change that are essential to help obtain a global understanding of environmental change past, present, and future. Further details are given below in section 2 (see also Lowe, 2018a).

1.3. *Please comment on what the New Zealand research sector, aligned with the International Union membership, can offer to international researchers, with a view to creating potential partnership, or cement New Zealand's involvement, in the activity over the long-term.*

Very strong partnerships have been developed by New Zealand and Australian researchers through the IFGs and projects that are supported by INQUA. The advent of the Australasian INTIMATE project led to the more-or-less entire Quaternary communities of New Zealand and Australia becoming involved to develop new ideas and to publish benchmark papers and interpretations and a new template for interpreting climate change from c. 30,000 years ago through to c. 8000 years ago (e.g. Barrell et al., 2013; Reeves et al., 2013a, 2013b). Although centered on Australasia, the myriad of connections between New Zealand and Australian researchers and counterparts all around the world means that international partnerships are strong and durable. For example, the INTAV executive comprises representatives from New Zealand, Canada, UK, Japan, and Switzerland. And every four years the global Quaternary research community assembles for the full INQUA congress (held in Japan in 2015 and to be held in the Republic of Ireland in 2019), with New Zealand an important voice on the International Council and with numerous scientific sessions being convened by New Zealand and other scientists, i.e. the INQUA community provides one of the best examples of strongly connected and productive relationships in science that is tackling globally-relevant problems. New Zealand Quaternary scientists are extremely productive and effective given the small size of our community.

1.4. *Please comment on what has been planned for New Zealand to leverage off the opportunities identified in 1.2 or 1.3. If these are ongoing activities, please comment on the progress since last year's report.*

As evident below (and also reported in Lowe, 2018a), the current IFGs and projects being undertaken in New Zealand are set to run until the INQUA congress in Dublin in July 2019. As noted in section 2, a number of conferences and workshops were held in 2018 under

the auspices of the INQUA IFGs and projects. Because 2019 is the year of the full congress of INQUA in Dublin, workshops and meetings for the first part of 2019 have been curtailed because most efforts of the New Zealand Quaternary research leaders are instead being directed towards developing and convening numerous sessions (symposia) for the congress. For example, SHAPE (Dr Drew Lorrey), SHeMax (Dr Lynda Petherick), and INTAV (Prof David Lowe) are convening multiple sessions in Dublin (see http://www.inqua2019.org/special-sessions/). Considerable funding from INQUA, and also to a lesser extent from AQUA, is available to help support ECRs attend the congress as bursaries (http://www.inqua2019.org/bursaries/). A number of New Zealand-based ECRs will be supported in this way (applications are due by 16 January 2019).

An important direct output of the INTAV international tephra meeting that was held in June-July 2018 in Romania is to be a special issue of the *Journal of Quaternary Science*. The INTAV executive has received formal support from *JQS* to publish up to 40 papers in a special issue entitled "Crossing New Frontiers: Extending Tephras as a Global Geoscientific Research Tool (EXTRAS Project)". The issue, being edited by Peter Abbott (UK/Switzerland), Britta Jensen (Canada), Daniel Veres (Romania), Takehiko Suzuki (Japan), and David Lowe (New Zealand), is scheduled to be published in January 2020.

2. INFORMATION RELEVANT TO THE RESEARCH COMMUNITY IN THE PREVIOUS YEAR

2.1. Please list/update list of New Zealander(s) participating in International Union work programmes and/or the Union council(s).

Prof David Lowe
(University of Waikato):

(i) New Zealand representative of RSNZ (and for the New Zealand Quaternary science community) on the International Council of INQUA

(ii) Formal advisor to SACCOM, INQUA

(iii) Co-organiser of the "Crossing New Frontiers" tephra meeting held in Romania, June-July 2018

(iv) Immediate Past-President on the executive of INTAV, under the aegis of which the executive has proposed three tephra-focussed sessions for the full INQUA congress in Dublin, 2019

(v) Leader of the ongoing EXTRAS project of INTAV

(vi) Member of advisory editorial boards of *Quaternary International, Journal of Quaternary Science, Quaternary, Quaternary Geochronology*

(i) Co-guest editor of special issue of *Journal of Quaternary Science* on tephras (in preparation)

Dr Marcus Vandergoes
(GNS Science):

(i) Lead convenor of annual GNS Science Quaternary Techniques Short Course, Lower Hutt, 2018

Dr Andrew Lorrey (NIWA):

(i) New Zealand early career researcher representative on SACCOM, INQUA

(ii) Convenor of SHAPE workshop held in Wollongong, February, 2018

(iii) Co-leader of SHAPE, under the aegis of which the executive has proposed a SHAPE session for the full INQUA congress in Dublin, 2019

Dr Lynda Petherick
(Victoria University of Wellington):

(i) Leader of SHeMax

(ii) Convenor of SHeMax session at INQUA congress in Dublin, July 2019

(iii) Convenor of SHeMax meeting at INQUA congress in Dublin, July 2019

(iv) Vice-president of AQUA (2018-2020)

(v) Lead guest editor for special issue in journal Quaternary Research on SHeMax (open for submission, November 2019)

Prof Rewi Newnham
(Victoria University of Wellington):

(1) New Zealand representative on formal subdivision of the Holocene series/epoch (see Walker et al., 2018)

(2) Regional Editor (Asia and Australasia), *Journal of Quaternary Science*

(3) Member of advisory editorial board of *The Holocene*

Prof Andrew Mackintosh
(Victoria University of Wellington):

(i) Lead Author, Intergovernmental Panel on Climate Change (IPCC) "Special report on the ocean and cryosphere in a changing climate" (in preparation: https://www.ipcc.ch/report/srocc/)

(ii) Review Editor and member of advisory editorial board of *Frontiers in Cryospheric Sciences*

Dr Helen Bostock (NIWA):

(i) Immediate Past-President (New Zealand) of the Australasian Quaternary Association (AQUA) and member *ex officio* of AQUA committee (2012-2018)

Dr Carol Smith (Lincoln Univ.):

(i) Co-editor of *Quaternary Australasia* (newsletter of AQUA)

Dr Andrew Rees
(Victoria University of Wellington):

(i) Member of AQUA committee (2016-18, 2019-20)

Assoc Prof Peter Almond
(Lincoln University):

(i) Member of AQUA committee (2016-18, 2019-20)

Associate Prof Alan Hogg (Radiocarbon Dating Laboratory, University of Waikato):

(i) Member of editorial advisory board of *Quaternary Geochronology*

2.2. *Please list International Union activities over the last year of relevance to your research community and describe how these have been communicated.*

Conferences involving INQUA-related IFGs and projects included the following.

(1) SHAPE: a workshop entitled "Southern Hemisphere Assessment of PalaeoEnvironments (SHAPE) Workshop: Quaternary variability, abrupt change and tipping points", convened by Dr Drew Lorrey, was held 2-3 February, 2018, at the University of Wollongong, NSW, Australia.

(2) GNS Science: the "Quaternary Techniques Short Course" for 2018 was held at the National Isotope Centre of GNS Science, Lower Hutt, 17-18 May, 2018. It was organized by Drs Marcus Vandergoes, Karyne Rogers, Jocelyn Turnbull, and Liz Keller together with Helena Cowan and Ren Wanden (GNS Science) with participation from 17 leading Quaternary researchers from GNS Science, Victoria University of Wellington, University of Otago, University of Waikato, and NIWA.

(3) SHeMax: a meeting of The Last Glacial Maximum in the Southern Hemisphere (SHeMax) project, convened by Dr Lynda Petherick, was held at the Morton Bay Research Station (MBRS) of the University of Queensland on North Stradbroke Island from 28-30 June 2018. A report for the meeting was compiled by Ellerton (2018).

(4) INTAV: the International Focus Group on Tephrochronology and Volcanism (INTAV), held a conference from 24 June-1 July, 2018, the Cheile *Gradistei* Fundata in the village of Moieciu de Sus, a panoramic resort location near Brașov between the Piatra Craiului and Bucegi Mountains in the southern Carpathians, Transylvania, Romania. Daniel Veres (Romania) and Ulrich Hambach (Germany) convened the meeting along with Siwan Davies (Wales, UK), Peter Abbott (UK/Switzerland), Britta Jensen (Canada), Takehiko Suzuki (Japan), and David Lowe (New Zealand). The proceedings were prepared by Hambach and Veres (2018) (see https://www.bayceer.uni-bayreuth.de/intav2018/en/key_dates/5001/1/16443/INTAV_Programm_final_vers2-2.pdf). Several reports of the meeting have been published, including those of Lowe (2018b, 2018c, 2018d) and Karátson et al. (2018). Several New Zealand-based ECRs (Dr Jenni Hopkins, Leonie Peti) were supported financially by grants from INQUA.

(5) AQUA: AQUA held its biennial meeting in Canberra 9-14 December, 2018, at Crawford Precinct, Acton Peninsula, Canberra (convenor Dr Scott Mooney). As well as a full conference, a three-day pre-conference field trip "High altitude environments of Eastern Australia" was also run 5-8 December. This meeting follows the very successful biennial meeting of AQUA that was held in Auckland in December, 2016 (see Lowe, 2018a).

Each of these meetings/workshops provided further opportunity for new research and collaborations and for ECRs to engage with the established Quaternary community of both New Zealand and Australia.

(6) Developing a formal subdivision of the Holocene involved input from Prof Rewi Newnham (Victoria University of Wellington). The proposal on which this subdivision is based was submitted by the Subcommission on Quaternary Stratigraphy, approved by the International Commission on Stratigraphy, and formally ratified by the Executive Committee of the International Union of Geological Sciences on 14th June 2018. A paper to this effect has just appeared online in Episodes (Walker et al., 2018) and another one is soon to be submitted to JQS.

(7) Helen Bostock and David Lowe (Bostock and Lowe, 2018) published an update of progress towards formalisation of the Anthropocene. After several years of meetings and discussion, the Anthropocene Working Group (AWG) overwhelming supported the idea that the Anthropocene is functionally and stratigraphically different from the Holocene, recommending that it started about 1950 (coincident with the 'Great Acceleration'). Members of the AWG voted in favour of the formalisation of the Anthropocene at the level of epoch. This means that, following ratification from several other organisations, the Holocene Epoch is to be terminated, but both the Anthropocene and the Holocene are to remain within the Quaternary Period and Cenozoic Era. In the next few years the AWG will submit a final proposal to the International Commission of Stratigraphy, in order for the Anthropocene Epoch to be formally included in the Geological Time Scale.

Communication in all of these activities has been made via published papers in the international literature as well as via notices and reports in newsletters including *Quaternary Australasia* (AQUA), *Quaternary Perspectives* (INQUA), *IAVCEI News, Geoscience Society of New Zealand Newsletter,* multiple Facebook sites, and individual organisational (focus group or project) webmail services. David Lowe also reported to the New Zealand Quaternary community at least eight times in 2018 with brief updates or surveys on activities and issues via an email list (~60 names) of the main active Quaternary researchers in New Zealand. These emails are also usually copied to Australian INQUA representative Dr Jessica Reeves (Federation University Australia).

3. ADDITIONAL COMMENTS

3.1. *Additional comments relevant to the International Union membership that you would like to share with the Society, MBIE, and/or the research community.*

Prof David Lowe was made an Honorary Life Member of INTAV at the tephra meeting held in Romania on 27 June, 2018.

REFERENCES

Barrell, D.J.A., Almond, P.C., Vandergoes, M.J., Lowe, D.J., Newnham, R.M., NZ-INTIMATE members 2013. A composite pollen-based stratotype for inter-regional evaluation of climatic events in New Zealand over the past 30,000 years (NZ-INTIMATE project). *Quaternary Science Reviews* 74, 4-20.

Bostock, H.C., Lowe, D.J. 2018. Update on the formalisation of the Anthropocene. *Quaternary Australasia* 35 (1), 14-16.

Ellerton, D. 2018. An overview of the final SHeMax meeting, North Stradbroke Island, Queensland, 28-30 June 2018. *Quaternary Australasia* 35 (2), 20-24.

Hambach, U., Veres, D. (editors) 2018. Book of Abstracts, *Crossing New Frontiers: INTAV International Field Conference on Tephrochronology, 'Tephra Hunt in Transylvania',* Moieciu de Sus, Romania, 24 June-1 July, pp. 1-160.

IPCC 2018. Special report on global warming of 1.5°C. Intergovernmental Panel on Climate Change, Geneva.

Karátson, D., Veres, D., Lowe, D.J. 2018. INTAV tephra conference "Crossing New Frontiers: Tephra Hunt in Transylvania", 24 June–1 July, 2018, Moieciu de Sus, Romania. *IAVCEI News 4/2018* (in press).

Lowe, D.J. 2018a. Quaternary research in New Zealand and relationship to the International Union for Quaternary Research (INQUA). Annual Report for 'Catalyst Fund: Influence' for 2017 (with Appendix A). School of Science, University of Waikato, Hamilton, 24 pp.

Lowe, D.J. 2018b. Quaternary science in New Zealand: report to the Catalyst Fund. *Quaternary Australasia* 35 (1), 10-14, with Appendix A "Summary of Quaternary-related research in New Zealand and relationship to International Union for Quaternary Research (INQUA) (17 pp.) at http://aqua.org.au/wp-content/uploads/2018/06/Quaternary-NZ-issues-summary-2018.pdf

Lowe, D.J. 2018c. Report: International tephra conference "Crossing New Frontiers: Tephra Hunt in Transylvania", 24 June–1 July, 2018, Moieciu de Sus, Romania. *Quaternary Australasia* 35 (2), 14-19.

Lowe, D.J. 2018d. Report on the INTAV international tephra conference "Crossing New Frontiers: Tephra Hunt in Transylvania", 24 June–1 July, 2018, Moieciu de Sus, Romania. *Quaternary Perspectives* 25 (2), 9-11. (Also available on the INTAV website: http://www.comp.tmu.ac.jp/tephra/intavtmu/top.html)

Reeves, J.M., Barrows, T.T., Cohen, T.J., Kiem, A.S., Bostock, H.C., Fitsimmons, K.E., Jansen, J.D., Kemp. J., Kraus, C., Petherick, L., Phipps, S.J., OZ-INTIMATE Members 2013a. Climate variability over the last 35,000 years recorded in marine and terrestrial archives in the Australian region: an OZ-INTIMATE compilation. *Quaternary Science Reviews* 74, 21-34.

Reeves, J.M., Alloway, B.V., Barrows, T.T. (editors) 2013b. Linking Southern Hemisphere records and past circulation patterns: The AUS-INTIMATE Project. *Quaternary Science Reviews* 74, 1-279.

Walker, M., Head, M.H., Berklehammer, M., Bjorck, S., Cheng, H., Cwynar, L., Fisher, D., Gkinis, V., Long, A., Lowe, J., Newnham, R.M., Rasmussen, S.O., Weiss, H. 2018. Formal ratification of the subdivision of the Holocene Series/Epoch (Quaternary System/Period): two new Global Boundary Stratotype Sections and Points (GSSPs) and three new stages/subseries. *Episodes* (in press), 11 pp. DOI: 10.18814/epiiugs/2018/018016

Signature:

Delegate: (Prof David J. Lowe)

Date submitted to the Society: 5 December 2018

CREATING A HAND-HELD MICROSCOPIC WORLD

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https://datacommons.anu.edu.au/DataCommons/rest/display/anudc:5991?layout=def:display

INTRODUCTION

Teaching Quaternary science techniques that require students to peer down a microscope to resolve tiny particles with 3D form can be pretty challenging. It becomes even more challenging as class sizes increase and teaching assistance decreases. But what if students could pick up and handle a pollen grain, a diatom or an ostracod. Enter the amazing technological advances associated with 3D printing. In recent years this has been transformative in the education sphere, leading to considerable educational benefits for students and teachers alike.

3D printed models give the user a better mental image, a tactile experience and a practical way to control orientation vagaries. 3D models also enable the student to investigate (as they do in the medical sciences) the fine scale structures and function of the sample in question. These models also enable students who find themselves in a position of disability to still have a meaningful engagement with the microscopic world. In particular, students with cognitive challenges that make microscopic work difficult, as well and people with eye injury or conditions of blindness.

3D models are also recognised as being best practice for the teaching of complex 3D forms, especially in the current learning environment where students tend to be under an increasing cognitive load through constant connection with the online world for both educational and social reasons. Comparative tests of the three typical approaches to teaching in this space show that students who learn primarily through the use of physical models perform significantly better in assessment than those students who rely solely on textbooks or 3D computer models (eg. Preece, et al., 2013).

In the biological sciences most of the focus has been in medicine, primarily through CT scanning and the subsequent 3D production of complex anatomical models. There are, however, numerous lifeforms that are microscopic and beyond the resolution limit of CT scanning. These lifeforms present students with the cognitive challenge of comprehending their 3D form from traditional 2D presentations in texts, or when viewed down the light microscope. Research has shown that hand-held 3D models can help overcome many of the cognitive obstacles associated with the study of complex anatomical structures, providing students with a more enjoyable learning experience and, at the same time, developing a learning environment that encourages deeper engagement (Preece, et al., 2013; McMenamin, et al., 2014).

Several labs around the world have taken up this challenge for the microscopic world (Perry, et al., 2017; Holt and Savoian, 2017), with some now making their models freely available online, including our own (3D pollen project; Palaeoworks). The Australian pollen types we have imaged and rendered for 3D printing are based on those commonly encountered in a site we 'inflict' on our undergraduate students, but many more could and should be developed.

It's with thanks to ANU Teaching and Education Grant we were able to develop the following design procedure for imaging and 3D printing twelve different pollen types from our reference collection, removing them from the virtual world and making them a hand-held reality for our classrooms as well as for community outreach.

DESIGN PROCEDURE

The design procedure is an adaptation of methods used elsewhere and best described by Katherine Holt and colleagues at Massey University, New Zealand (see Holt and Savoin, 2017; Perry et al., 2017). The key step in the whole process is acquiring an image stack; a vertical sequence of 2D images taken at defined intervals. When the images are joined together it is possible to create a three-dimensional model from this stack of two-dimensional images. It is the quality of the stack that determines the quality of the 3D model and, ultimately, the quality of the print itself.

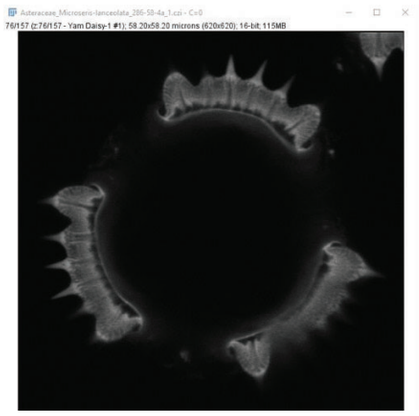
What follows is a summary of the process we developed for the imaging and 3D printing of Australian pollen. The full description, in particular detailed tips associated with the rendering steps, will be made available on the Palaeoworks.com website soon, along with the 3D print files we have already developed.

1) *Slide selection*: While Holt and Savoin (2017) processed fresh material and utilised a specific mounting medium, 2,2'-Thiodiethanol (TDE), we used existing pollen reference slides from the extensive Australian Pollen and Spore Reference collection, held and maintained by Archaeology and Natural History at the ANU. Slides were selected based on abundant pollen content that were also in good condition, well aectolysed and with little to no extraneous material. While the refractive index of our material may not be as good as the TDE protocol outline by Holt and Savoin (2017), we found there was little difference in image quality between the different standard mounting mediums; silicone oil, glycerine jelly, glycerol.

2) *Image stack*: As with Holt and Savoin (2017) we used confocal microscopy to capture the volumetric stack (Figure 1). Instructions associated with specific confocal systems are best dealt with by local area experts. In the case of ANU, this is the Centre for Advanced Microscopy (CAM) and the Zeiss Confocal LSM 780 system. While training is necessary the skills to operate the confocal system are quickly acquired.

3) *Conversion of image stack to a virtual 3D model*: Once the image stack was acquired, it was turned into a 3D model. To do this we used Drishti, a volume exploration and presentation tool developed at ANU that converts 2D image stacks into 3D models.

A. *File conversion:* An image stack produced by the confocal microscope software needs to be converted into a file type that can read by the rendering software. Fiji (https://fiji.sc/) is a freely available open-source distribution of the ImageJ software that can read and convert image file types used for scientific imaging (Schindelin et al., 2012).



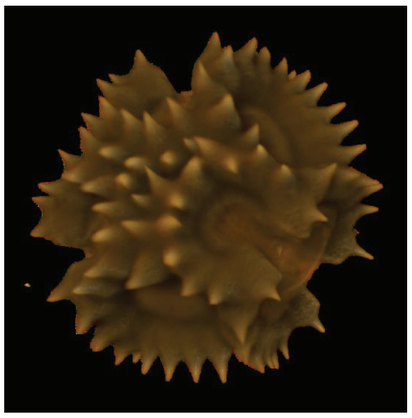
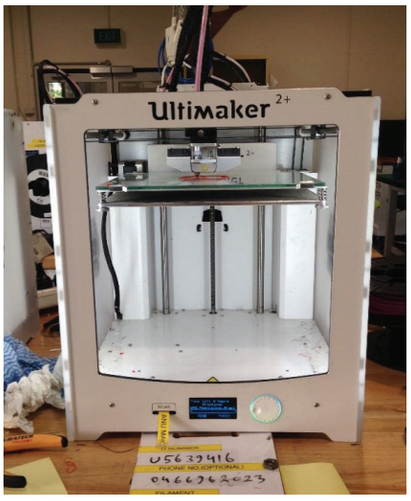


Figure 1: Single 2D image from volumetric stack of *Microseris lanceolata* acquired from the Zeiss Confocal LSM 780 system at ANU.

Figure 2: Virtual 3D model of *Microseris lanceolata*. Rendering carried out in Drishti.

All photo credits Janelle Stevenson



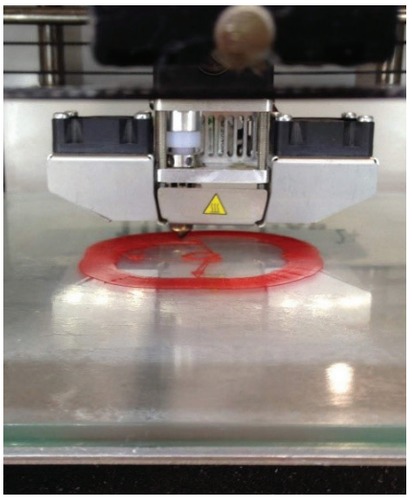


Figure 3a and b: Ultimaker 2+ printer in operation at the ANU MakerSpace (left) with close-up of print head laying down heated filament onto the glass buildplate.

B. *The virtual 3D model*: To create this we used Drishti, a volume exploration and presentation tool. It comprises five modules, two of which were used here; Import and Renderer (Figure 2). The software is downloadable as a single package with the latest version and documentation available through GitHub (https://github.com/nci/drishti). You can also use the ImageJ 3D Viewer plugin to produce your virtual 3D model (Schmid et al., 2010). We found it necessary to manually input information to render the object in correct proportions as we discovered that many of the pollen grains on our reference collection slides, particularly the older ones, were lacking a sufficient Z dimension, as many had been slightly 'flattened' during the slide making process. This would be the advantage of processing fresh material as was done by Holt and Savoin (2017) instead of relying on existing material.

4) *Preparing a 3D model for printing*: We used the open-source software Meshlab to fill in any holes, and remove unwanted features and convert our Drishti generated PLY files to STL format, the file format commonly used by 3D printing software. Stack Overflow hosts tutorials and solutions addressing specific problems for Meshlab. If you have generated good quality 3D models through the Image-J 3D Viewer plugin it is possible to go straight from Image-J to Meshlab.

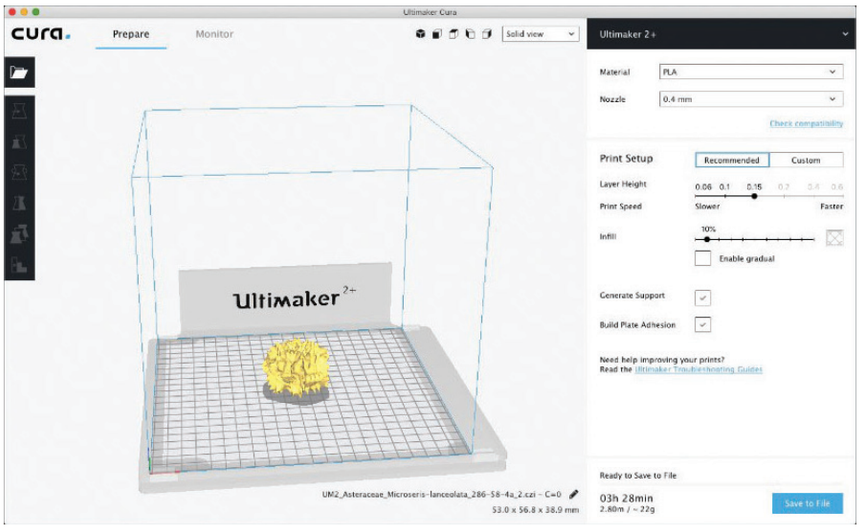
5) *Printing*: Once you have your mesh file in STL format you can start the print preparation steps. Our project is utilising two facilities for 3D printing; the ANU MakerSpace for our prototype printing and a commercial printing service for our teaching sets. The ANU printing was carried out on an Ultimaker 2+ printer, a filament printer, meaning that the printing medium is supplied in the form of a spool of thin plastic filament that turns viscous when heated. This makes it possible to print detailed features layer by layer (Figure 3). This is a relatively cheap and accessible form of printing and is sometimes referred to as additive manufacturing. The plastic filaments that are commercially available of course vary in their colour, thickness and other properties, so when choosing a filament type keep in mind the project goals as well as budget and seek advice from other users and experts. For our prototypes the basic 2.85 mm PLA filament supplied by the ANU MakerSpace (for free – so another incentive) was adequate.

This type of print is executed in a pattern that is calculated prior to the printing process. For the Ultimaker printers this calculation is done in Cura, freely available software for displaying, manipulating and preparing meshes for printing. The STL mesh is loaded onto a virtual buildplate that simulates the buildplate of the physical machine. In this view, the model can be moved, rotated, and scaled in three dimensions. The model can also be viewed in default, X-ray, and layer views, allowing the user to observe the position, orientation, and integrity of the model and to preview the final build before committing to the final print (Figure 4).

Before the mesh is prepared for printing though, you need to set up the desired printing parameters. This includes choosing the right printer type; selecting the printing material and nozzle size to match those on the printer; and choosing the printing speed, infill levels, and the use of supporting structures. Why mention this? Because these parameters impact how robust the final product is, how much filament is needed and importantly how long the printing process takes. In our project, we opted for speed and economical use of material. Once the parameters are set, the mesh is prepared for printing. A commercial printing service naturally does this step for you, you simply send them the mesh (STL) files.

While printing a small 3D model for display is a relatively straightforward process, depending on the size and complexity of the model, printing can take several hours. Complex objects sometimes also require supporting structures that can be generated in the software but are later removed with pliers (Figure 5). It was also our experience that monitoring the printing process intermittently was time well spent, to avoid greater loss of time, money and material, as things routinely go awry with shared printers.

Figure 4: Preparing the print file of *Microseris lanceolata* in Cura for the Ultimaker 2+ printer



FINAL COMMENTS

It should be noted that processing and manipulation of a faulty scan is no replacement for a good quality starting image. So, spend the time required to find or prepare good quality samples and then capture as clean, complete and undistorted an image as possible. Turning microscope observations into 3D prints is a multi-stepped process and so you need to set aside ample time for this type of project. Plan for contingencies, be prepared to learn through trial and error and most importantly share your experiences and outcomes with others.

Palaeoworks now has 12 models of Australian pollen available for printing in STL format that we are happy to share with researchers across our community and elsewhere (Figure 6). To download them just

go to the Palaeoworks.com website or contact Janelle directly (Janelle.Stevenson@anu.edu.au).

REFERENCES

Holt, K.A., Savoian, M.S., (2017). Epi-fluorescence microscopy and 3D printing: An easily implemented approach for producing accurate physical models of micro- and macroscopic biological samples. In: Méndez-Vilas, A. (ed.) *Microscopy and imaging science: practical approaches to applied research and education*. Formatex Research Centre, Badajoz, Spain. 697-702.

McMenamin, P.G., Quayle, M.R., McHenry, C.R., Adams, J.W., (2014). The Production of Anatomical Teaching Resources Using Three-Dimensional (3D) Printing Technology. *Anatomical Sciences Education* 7: 479–486.

Perry, I., Szeto, J-Y., Isaacs, M.D., Gealy, E.C., Rose, R., Scofield, S., Watson, P.D., Hayes, A.J., (2017). Production of 3D printed scale models from microscope volume datasets for use in STEM education. *EMS Engineering Science Journal 2017* 1(1): 002.

Preece, D., Williams, S.B., Lam, R., and Weller R., 2013. "Let's Get Physical": Advantages of a physical model over 3D computer models and textbooks in learning imaging anatomy. *Anatomical Sciences Education* 6: 216-224.

Schindelin, J., Arganda-Carreras, I., Frise, E., Kaynig, V., Longair, M., Pietzsch, T., Preibisch, S., Rueden, C., Saalfeld, S., Schmid, B., Tinevez, J.Y., White, D.J., Hartenstein, V., Eliceiri, K., Tomancak, P., Cardona, A., (2012). Fiji: An open-source platform for biological-image analysis. *Nat Methods* 9: 676–682.

Schmid B, Schindelin J, Cardona A, Longair M, Heisenberg M. (2012). A high-level 3D visualization API for Java and ImageJ. *BMC bioinformatics* 11: 274.

WEBSITES REFERRED TO IN TEXT

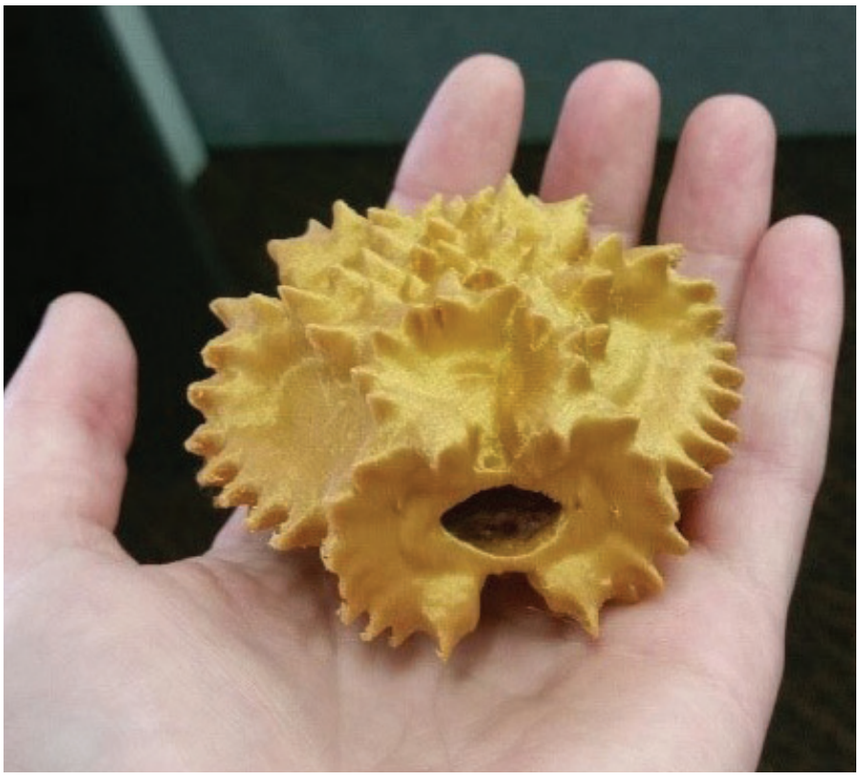
https://3dpollenproject.wixsite.com/main

http://palaeoworks.com/

http://www.meshlab.net/

https://stackoverflow.com/questions/tagged/meshlab

Figure 5 a and b: Initial print of *Microseris lanceolata* with structures in place (left) and with structures removed (right).



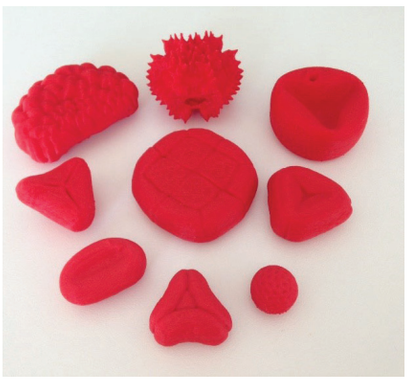


Figure 6a and b: Final product. Palaeoworks 3D printed pollen protoypes to be used in our undergraduate teaching and outreach activities (left) and models already shared with Haidee Cadd and Martin Ankor University of Adelaide (right). For print (STL) files go to Palaeoworks or contact Janelle.Stevenson@anu.edu.au

REPORT ON THE 13TH INTERNATIONAL CONFERENCE ON PALEOOCEANOGRAPHY, SYDNEY, 2019

Helen Bostock

School of Earth and Environmental Sciences, University of Queensland, QLD, Australia

The triennial International Conference on Paleoceanography was recently held at the University of New South Wales in Sydney. This is the first time that this conference has been held in the Southern Hemisphere since the first conference held in Zurich in 1983. ICP13 was opened with a "Welcome to Country" by local aboriginal elder Dr Peter McKenzie and an introduction by the University of NSW marine biologist and Dean of Science; Professor Emma Johnston.

The ICP Conference has a unique format with only 24 invited keynote talks from a mix of early career to experienced researchers, and 4 plenary talks from high profile researchers in paleoceanography or adjacent disciplines (e.g. ice core research). All other delegates present their work during the lively poster sessions. The conference themes for ICP13 were: Proxy development, new models and statistical tools; Geobiology and new frontiers paleoclimate changes with biology and evolution; Carbon climate feedbacks across time scales; Ocean circulation and system dynamics; Role of Southern Hemisphere processes; Ice sheet/ocean interactions; drivers and impacts. Under proxy development we heard talks about clumped isotopes (Nele Meckler), GDGTs (Susanne Fietz), oxygen isotopes in gypsum (Yama Dixit) and using proxies to look at climate variability (Thomas Laepple). In the geobiology space we had talks about deep sea coral mounds (Jurgen Titschack), ostracod evolution (Moriaki Yasuhara) and aDNA from deep sea cores (Linda Armbrecht).

In Carbon-climate feedbacks theme talks covered modelling possible variations in the biological Redfield Ratio (Katsumi Matsumoto), Cenozoic hyperthermal events (Lucas Lourens), Cenozoic polar amplification (Matt Huber) and how changes in calcification can alter the carbon cycle (Gert Jan Reichart). Ocean circulation and dynamics was explored by looking at changes in the El Nino in the Indian Ocean (Kaustubh Thirumalai), changes in the north Pacific during the melting of the Laurentide ice sheet (Summer Praetorius), changes in hydrology and vegetation in the Sahara and Sahel regions (Francesco Pausata), as well as using Neodymium isotopes to understand circulation changes in the Atlantic across the Mid-Pleistocene Transition (Kazuyo Tachikawa). The role of the Southern Hemisphere was reconnoitred through presentations on the influence of the Southern Ocean going into the glaciation (Karen Kohfeld), Antarctic sea ice changes through the late Quaternary (Xavier Crosta), a thorough multi-model review of the impact of millennial-scale changes in oceanic circulation on atmospheric CO_2 (Julia Gottschalk) and on the use of annually banded corals from the Great Barrier Reef and around the world to understand variability in climate over the last glacial cycle (Thomas Felis). Results from recent coring on the Great Barrier Reef were also used to look at past sea level changes (Jody Webster) and other talks looked at sea level-ice sheet-solid earth interactions (Natalya Gomez), a new Pliocene sea level curve (Tim Naish) and some modelling work looking at differences between glacials (Ed Gasson) in the ice-sheet-ocean interactions theme.

The plenary talks covered a range of different topics with Ed Brook talking about evidence for rapid changes in CO2 in ice cores during millennial scale events. Andy Ridgwell showed some new results of linking climate models with ecological models to look at how changes in ecosystems influence the global carbon cycle. Axel Timmermann showed some new modelling results investigating how past climate change influenced human migration out of Africa and interactions between Neanderthals and *Homo sapiens* as they spread north into Europe. Kim Cobb (via remote talk) discussed El Nino from coral records from the central Pacific and how and why it varied in the past. She also spent some of her talk on current and future climate change and everyone aiming to reduce their carbon footprint, especially by #flyingless. Her talk is available on YouTube. There were a wide range of poster presentations including 2 on automated recognition and picking of forams, which could be a big time saver for many of us in the future. Thus the talks and posters covered a wide range of paleoceanographic archives from nannos, tropical and deep sea corals, to ice cores, lots of different geochemical proxies, and age scales covering the Cenozoic through to the last 2K and into the future, including climate and ecological modelling on every different scale.

There were other talks on recent International Ocean Discovery

Program expeditions to the west coast of Australia (Stephen Gallagher) and the latest results from GEOTRACES (Bob Anderson). There was a special tribute on the achievements of Professor Wally Broecker, who died earlier this year, and his 7 decades of scientific research in ocean geochemistry and paleoceanography (Jerry McManus). Wally made some major contributions to the field including coining the ideas and phrases of "Global Warming", "Great Ocean Conveyor Belt", "Abrupt climate change", and "Ocean Acidification". He was in many ways one of the founders of the field of paleoceanography.

On the last day of the conference there was a book launch at lunch time of Elizabeth Truswell's new book "A Memory of Ice" published by ANU press, on her participation in the Deep Sea Drilling Program Leg 28 expedition to Antarctica in 1973. Liz is a palynologist interested in past vegetation changes in Antarctica during the Cenozoic and was one of the first women to sail as a scientist on the DSDP. (Editors note: Helen Bostock provides a report on Truswell's book launch in this edition of Quaternary Australasia.)

While the science schedule was busy, with additional side workshops and meetings prior and during the conference, the social schedule was equally eventful. At the ice breaker there was aboriginal singing, dancing and didgeridoo, with some audience participation. The conference dinner, which involved a cruise on Sydney Harbour at sunset was one of the highlights of the social program. The other highlight of every ICP is the Paleomusicology concert where paleoceanographers entertain us with their musical talents and sing and play a range of different music ranging from singalong songs to improvised piano pieces. The concert also included a science parody "Cover of the Science Mag" about getting your work published in Science by Martin Kölling (cover of Dr. Hook's "Cover of the Rolling Stone" originally written by Shel Siverstein, 1972). (You can check it out on YouTube https://youtu.be/-Ux3-a9RE1Q). There was also a field trip to Wombeyan Caves and walks along the Sydney coast, tours of the Opera House and pubs in the Rocks, not to mention a surf lesson at Bondi Beach. It was a very busy week for most of us!

ICP13 was a great success with >400 participants from all over the world attending and sharing their latest research in paleoceanography. It was a fantastic opportunity to catch up with local and international collaborators and develop new future collaborations. By holding the conference in Australia, it was a great way to bring the focus of paleoceanography to the Southern Hemisphere. It was motivating to see so many of the Australian and New Zealand researchers and students at the conference, showcasing the great work that is being undertaken in this part of the world. Congratulations to the two New Zealand PhD students; Greer Gilmer (University of Otago) and Nick Hitt (Victoria University, Wellington) who received poster awards.

More photos and comments on the ICP13 facebook page and twitter at #ICP13

Attendees at ICP13 'Under the Southern Cross'. Photo credit: ICP13.

UPDATE: SHeMax PROJECT
(THE LAST GLACIAL MAXIMUM IN THE SOUTHERN HEMISPHERE)

Lynda Petherick (on behalf of Jamie Shulmeister and Jasper Knight)

School of Geography, Environment and Earth Sciences, Victoria University of Wellington, New Zealand

We had a great SHeMax Project session at INQUA, with a range of exciting new original research presented in a combination of talks and posters. We were extremely happy to have good regional representation, with work from around the Southern Hemisphere presented. Outstanding keynotes were delivered by Jennifer Fitchett (University of the Witwatersrand), Kat Holt (Massey University) and Craig Sloss (Queensland University of Technology). Our SHeMax-sponsored delegates Stella Moreiras (Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales) and Haidee Cadd (University of Adelaide) also gave excellent presentations.

In addition to the session, we held a SHeMax meeting discussing the future directions of the project in the next inter-congress period (2020-2023). The first iteration of SHeMax (2016-2019) aimed to investigate climatic and environmental variability across the Southern Hemisphere (20-80 oS) for the period 35-15 ka. We have made good progress through a series of workshops, a review paper (currently in revision), conference sessions and an upcoming Special Issue of *Quaternary Research*. However, there are still many unresolved questions from our original proposal. Based on our current understanding, the community discussed avenues for exploration, coming up with three new themes:

What were the drivers/modes of climatic variability for the period 35-15 ka?

How did humans impact the landscape?

What was happening in terms of land-sea interactions (e.g. monsoon, ENSO)?

Haidee Cadd accepting her travel award from Jamie Shulmeister.
Photo credit: Valerie Shulmeister.

We expanded the spatial range to the equator and broadened the project with the aim to engage more with archaeologists, coastal/sea level experts, climatologists, oceanographers and South American researchers. We will do this through a series of multidisciplinary workshops to be held around the Southern Hemisphere, starting with a joint workshop with CABAH (The ARC Centre of Excellence for Biodiversity and Heritage) immediately prior to the AQUA conference in July 2020. The workshop will likely be held at James Cook University, Cairns. Details to come.

As mentioned, we have a Special Issue of *Quaternary Research* that is now open for submission (closing late 2019, publication ~May 2020). The scope of the issue is to explore the LGM in the Southern Hemisphere, through the presentation of original research and review papers. For more information, please contact lynda.petherick@vuw.ac.nz.

We now have over 75 people involved in the SHeMax Project, which is exciting. If you are interested in the project and/or want to join our mailing list, please email lynda.petherick@vuw.ac.nz. We are also on Facebook (Group name: SHeMax - Southern Hemisphere Last Glacial Maximum), and now on Twitter @Projectshemax. Our website is in the works - watch this space. Thanks to all who have, and are, contributing to the project. Looking forward to the next 3 years!

THE MOYJIL DILEMMA: PEOPLE AT 120ka, FACT OR FICTION?

Jim Bowler

School of Earth Sciences, University of Melbourne, Victoria, Australia

ABSTRACT

The publication earlier this year of six papers on the presence of clifftop edible marine shells near Warrnambool with implications of human agency has been greeted by various levels of disbelief. Dated here with unusual levels of age reliability at 120ka, the implications of doubling the age of human occupation generate understandable levels of scepticism. While direct archaeological evidence of people is lacking, the associated geological data present a different level of conviction. The collective evidence of age, edible marine shells, extensive fire and patterned relationships including stones in the wrong places, correlation between small stones and high fire effects combine to suggest intelligent selection. Despite the absence of direct evidence, tools, faunal remains let alone human remains, the presence of six independent lines of evidence lead inevitably to one conclusion; people were already present at 120ka. This follows the Ockham's Razor principle where a single explanation explains all. It is time now to ponder those wider implications.

INTRODUCTION

Despite high level peer group scrutiny, the publication in early 2018 of the series of papers in the Proceedings of the Royal Society of Victoria, suggesting 120ka occupation has understandably fallen below the level of general public acceptance. To seriously suggest such total revision of Australia's human history from 65ka at Kakadu (Clarkson, et al., 2017) to 120ka on the southern coastal margin, is for most, a leap too far. The evidence however tells another story.

It is 33 years since Edmund Gill suggested presence of human agency in an ancient shell midden on the cliffed coastline at Warrnambool (Figure 1). That claim has raised more questions than answers. If it were not for the 120ka age, few would question its authenticity. Doubling the age of human occupation however is a different issue.

Following Warrnambool historian Jim Henry's 1981 lead, Gill in 1986 invited colleagues to a site inspection in the hope of evaluating the possible human agency. After two days, visitors including John Mulvaney, Jim Allen and others left with general levels of disbelief. Nothing was resolved.

Following Edmund's death soon afterwards, his colleague in Warrnambool region studies, Dr John Sherwood, maintaining Edmund's conviction, kept the issue alive. Publishing the work of Macquarie University Honours student, Hannah Nair (Nair & Sherwood, 2007) reiterated that question, "Could this be human?". Once more the scientific community did not respond.

As a participant in Gill's 1986 original site inspection, I retained a lingering suspicion he may have been right. In 2007, I approached John Sherwood suggesting a more systematic analysis. With John's agreement we established the research team, John, Steve Carey, Ian McNiven and myself. We undertook to test Gill's hypothesis for human agency of shell deposit and, where possible, to prove it wrong. The results are registered in the joint publication of six papers in the Proceedings of the Royal Society of Victoria. Discussion of those results forms the basis for this paper.

Our publication in those Proceedings resulted from long discussion. While seen as lacking the degree of archaeological certainty required for unequivocal human agency, the outcome was bound to be greeted by archaeological scepticism. Despite the reality of the journal's low impact in university measures of importance, on balance, the urgency to publish the primary data took precedence. The need to bring together this multi-disciplinary complex and the Proceedings of the Royal Society (PRSV) editor, Dr Bill Birch's readiness to publish all papers as a group clearly won the day.

The intellectual response has, with some relief, been somewhat muted with a minimum of sceptical outrage. It takes time for some of these issues to sink in; slow intellectual digestion is better than spontaneous objection. The RSV Proceedings have served us well. Time now to contemplate some implications.

This paper presents summary details of evidence and outlines the arguments that follow. It provides a starting point from which I specify the central lines of my conviction and the process by which I reach that conclusion.

Referencing: While best read with copies of the main published papers, this summary is designed to provide the line of argument rather than repeat published details.

To avoid repetitive cross-referencing, PRSV papers are defined alphabetically, A to F, through Sherwood's Prologue (Ref. A) to end paper by McNiven, et al. (Ref F). Additional references are listed in the normal way.

Copy of PRSV papers may be obtained at: http://www.publish.csiro.au/rs Proc. Roy Soc. Vict., V 130, Part 2

or by request to me: jbowler@unimelb.edu.au

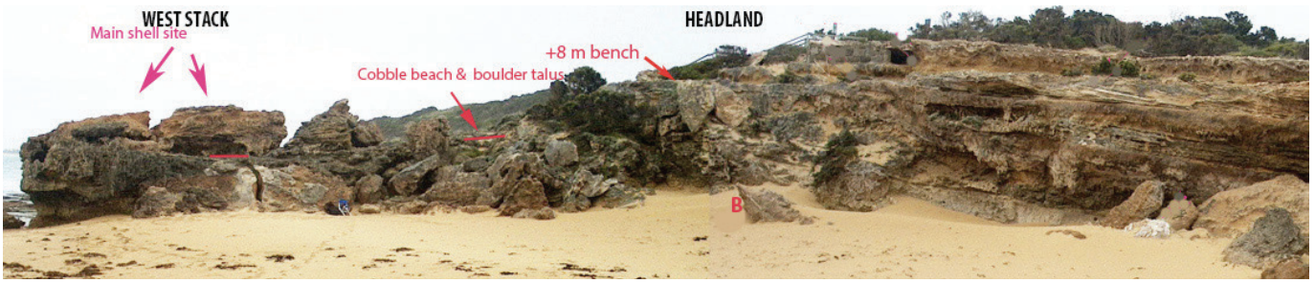
GEOMORPHOLOGY AND STRATIGRAPHY

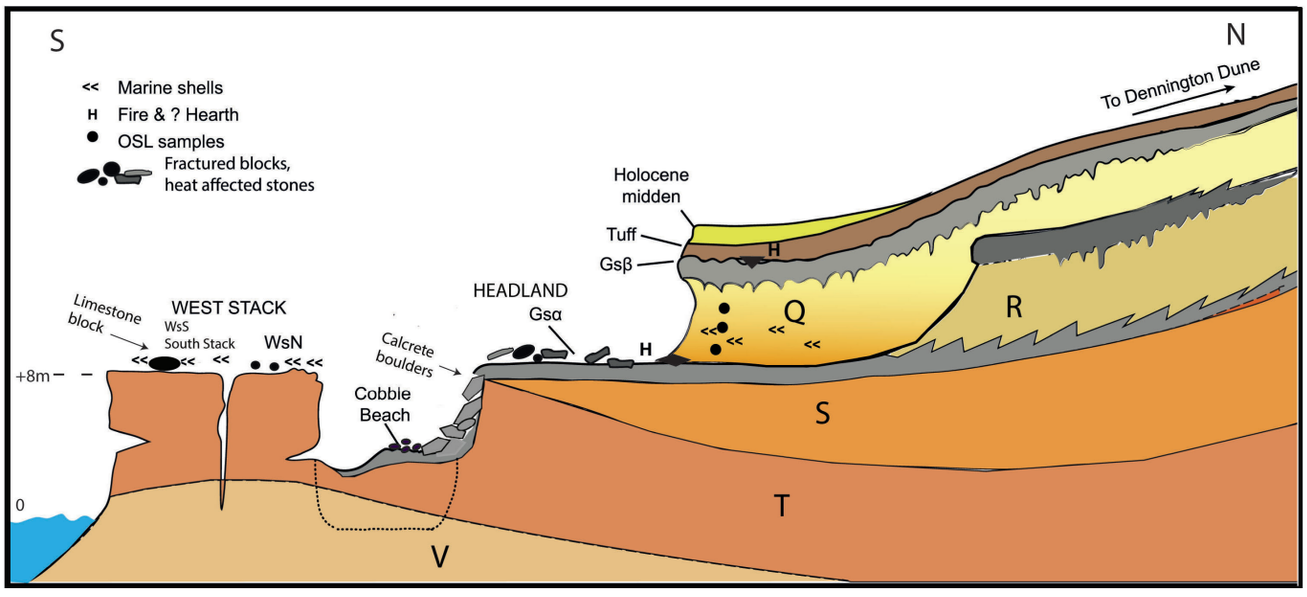
The site is located on exposures of a small off-shore stack (West Stack, fractured into two parts, West Stack South, WsS and West Stack North, WsN) and an adjacent cliffed headland platform (Figures 1 & 2). These lie in a context of repetitive high sea-level cliff and dune facies. The sequence is illustrated diagrammatically (Figure 3) with approximate ages, from oldest to youngest (Table 1). The geomorphic expression of upper Units Q & R aeolianites combine to form the landward dune (Dennington of Reekmann & Gill, 1981), the site of Warrnambool township. Those units carry the principle soil and groundwater calcrete exposures that define many elements of the site. A major erosion surface (Gsα, Ref. B)

Top: Figure 1: Location of the Moyjil site, formerly Point Ritchie, western margin of Hopkins River estuary.

Middle: Figure 2: View west showing cliffed line from stack in south to high (+12m) cliffs on headland. Block (B) collapsed from +8m level. Site location on western margin of boxed area, Fig. 1.

Bottom: Figure 3: Diagrammatic north-south section illustrating main components of Figure 2. Note location of fire place, Fp1 (H) on erosion surface at base of Q on headland. Three OSL sample sites, black dots in unit Q. For details, see text.





UNIT	AGE KA (APPROX.)
Q	120
R	230
S	~300
T	~400
V	>400

Table 1: Vertical succession of high sea-level calcarenites with associated calcrete horizons each exposed in outcrop listed here with approximate ages. For more specific age determination see text.

disconformably cuts across older aeolianites of S, T & V exposing the groundwater calcrete of Unit R. On West Stack transported marine shells occur in close association with darkened, fire affected stones on the erosion surface. Bare rock is exposed on both stack and headland, lacking any evidence of soil or signs of plant root structures. The erosion surface was devoid of vegetation. The main items of interest lie on that surface.

Three important markers help define the environmental sequence. Firstly, a layer of Tower Hill volcanic ash disconformably overlies the Unit Q aeolianite. Reliably dated to 35ka (Sherwood, et al., 2004), it forms an upper level of age control.

Secondly, extensive shattering of brittle groundwater calcrete (Unit R) is associated with fluid transport of shell and stone debris on West Stack, an event attributed by Carey, et al. (Ref. B) to probable seismic high energy interruption, an earthquake event. With equivalent expression on both stack and headland, this acts as a virtually instantaneous time marker over the main site exposure. It is designated as the *"Z-event"*. A north to south movement of fluidised shell and stone debris at that moment require connection between stack and headland at that time. Separation by collapse of the connecting bridge may well have been due to that seismic shock.

Thirdly, marine abrasion represented by potholes on West Stack finds equivalent examples in a collapsed block, Block B in Carey, et al. (Ref. B). When returned to its original position, it confirms abrasion on the headland identical to that on West Stack. That elevation at +8 m (Figure 3) provides direct indication of last interglacial sea-level (Hearty, et al., 2007).

Additionally, a cobble beach of +6m lies on the irregular surface connecting stack to headland (Figures 2 & 3). Wave abraded calcrete with fragmented shells lie at the toe of a boulder slope leading north to join the erosion surface Gs alpha. The cobble location implies separation of the stack-headland link involving collapse of the northern cliff before +6m marine action. This stratigraphic chronology was refined by direct dating of Units Q and R aeolianites.

OSL & TL DATING

Three samples from aeolianite Unit Q (Figure 3), with one from below the erosional disconformity in Unit R, combine to produce the OSL dated succession (Table 2). Unit Q results accord with stratigraphic estimates. Unit R relates to a previous MIS 7 high sea level.

When calcrete blackening effects of fire were established, 3 blackened stones were submitted for TL analyses to test the age of fires. Results (Table 3) once more accord with events of last interglacial age.

This presents a new aspect of this site. Ages of high sea-level, dune accretion and fire are all relatively synchronous. The controlling process remained to be identified.

UNIT	OSL AGE
unit Q2 MR1	126.7 ± 6.9
unit Q2 MR2	136 ± 8
unit Q2 MR3	121.0 ± 7.2
unit R MR4	239 ± 17

Table 2: OSL analyses, from Table 5 in Sherwood et al. (2004). (Ref. C)

SAMPLES	TL AGE
W4697 1	109±8
W4697A	93±7
W4698	129±12
W4698A	143±14
W4699	109±7

Table 3: Thermoluminescent results from 3 small black stones, reflecting age of thermal transfer to within last interglacial. Note two samples each from W4697 and W4698. Analyses by David Price (Ref. E).

MIDDEN SHELLS

Recorded in detail by Sherwood, et al. (Ref. D), shells occur in two main settings within Unit Q. The main shell midden is confined to the stack. Occasional but environmentally important shells occur in headland dune sand. The dominant species are Turbo *(Lunella undulata)*, occasional limpet (*Sabia conica)*, several Haliotis shells and an otolith of estuarine Mulloway (Ref. D). Sharp edged shells indicate transfer without passage through the wave abrasive zone. In a thorough analysis addressing the question of possible bird versus people origin, Sherwood, et al. (Ref. D) conclude neither bird nor human origin can be discounted based on available shell evidence.

STONE PATTERNING

Following Z-event disruption and consequent disordering of shattered blocks, the pattern of multiple calcrete stones on the erosion surface reflects a degree of order between different components. A close relationship exists between stone size, shape and degree of stain intensity (Figure 12. in Ref E), a degree of ordering suggesting a process to be defined.

Other examples of ordering include balanced stones with examples of older over younger (Figures 4 & 5A). Frequent occurrences of dark grey surface stains involve more penetrating zonal rim effects especially on smaller blocks (Figure 14 in Ref. E). On West Stack, stained stones form an important component with fragmented shells in debris displaced by Z-event fluid injections (Ref B). Patterns of staining vary greatly across both stack and headland. The explanation becomes clearer considering the influence of fire.

FIRE

Fp1: Of many factors potentially responsible for dark surface discolouration, the possibility of fire remained an obvious one. The discovery in 2007 of a lenticular occurrence of dark brown sands with charcoal fragments (Figure 4. "place of fire" Fp1, Ref. E) lent substance to fire as the possible answer to staining. Charcoal was associated there with an important assemblage of small blackened stones, evidence of calcrete alteration in direct associate with fire.

The site was later excavated by McNiven (Ref. F). Its structure involved the movement of stones to form a pit unlike any natural depression on that Z-affected irregular calcrete surface. Was it a deliberate construction or accidental pit?

Darkened stones within the fire affected area are often dispersed; grouped in clusters separate from each other which require variation of the primary heat source. Such clusters suggest multiple use of the same site.

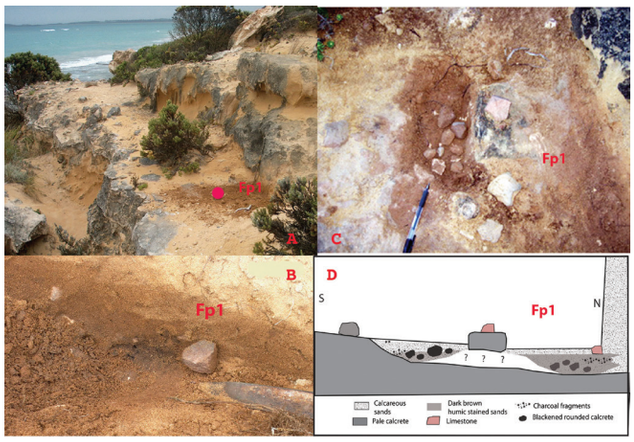


Figure 4: Collage of fire evidence, Fp1.

A. View west across headland bench below calcrete on unit Q sands showing location of fireplace (Fp1) in dark brown zone at base of small cliff cut into unit Q.

B. Dark brown lenticular zone with charcoal fragments at base of unit Q sands in Fp1. Knife blade 2.5 cm wide. Note cobble of red limestone with darkened fire affected excavated from cliff wall.

C. Vertical view of fire affected area surrounding a central calcrete block. Charcoal zone lies at base of right cliff wall.

D. Diagrammatic north-south cross-section through Fp1. Irregular depressions containing small black stones are separated by larger calcrete block carrying small red limestone atop central block and at base of wall in B. Clusters of small black stones in depressions on either side of the central block. See Figure 5.

Figure 5: Conversion of calcrete.

A. Two small fragments of fire-affected pinkish limestone (unit S) balanced on top of Unit R calcrete block in zone of fire area, Fp1. See Figure 4, C and D.

B. Small thoroughly blackened stones excavated either side of central calcrete block, Fp1 (Fig. 4, C & D).

C. White calcrete (Rcp) selected for heat treatment in wood fire.

D. Same stones after 40-60 minutes in wood fire, thoroughly blackened with rim traces of white calcined lime reflecting temperatures >700°C. Note similarity with stones from fire excavation in B above.

In his excavation analysis, McNiven concludes "*On balance, the broad range of discrimination criteria marginally point more towards CBS1* (my Fp1) *representing a cultural hearth and not exclusively a naturally burnt feature*". Meanwhile the actual role of fire remained to be established.

Experimental Analysis: The process of thermal alteration was tested and confirmed by a small experiment (Figure 5). White calcrete fragments, heated in a wood fire for nearly an hour were transformed to very dark grey, nearly black throughout (Figure 5D). The experimental results bore a very strong resemblance to the blackened stones recovered from small excavation below the level of charcoal in Fp1 (Figure 5B).

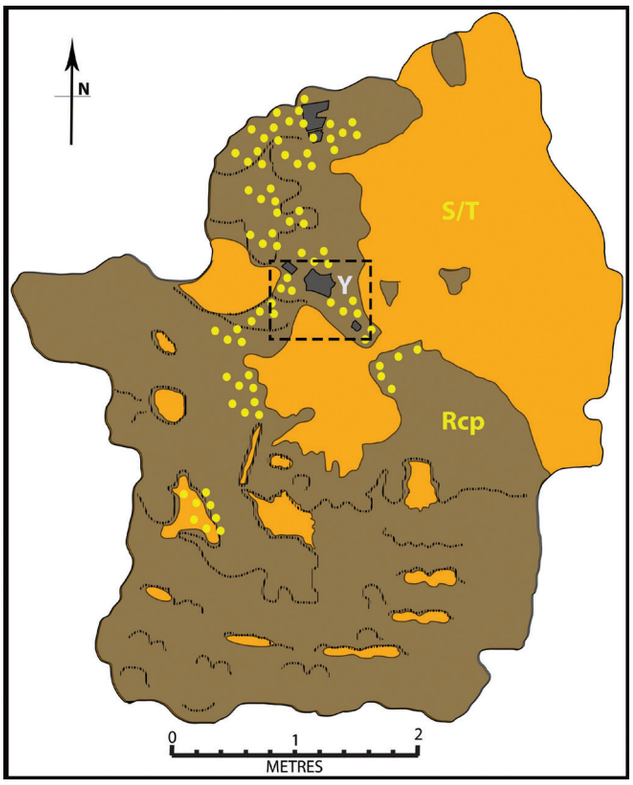
Magnetic Susceptibility: To test the hypothesis that change in colour on heating was reflecting a change in iron status, a susceptibility study tested for any associated changes in magnetic intensity. The results of some 70 measurements demonstrated a close correlation between depth, intensity of colouration and susceptibility signal. Susceptibility offered yet another link to the size-shape correlation (see Figures 19-21, Ref. E). It followed the morphologic succession as in Table 4. Something was happening beyond the levels of natural weathering or wildfire capability. Multiple fires are recorded on bare rock surfaces. Exposed calcrete surfaces on both stack and headland carry no evidence of root channels. Devoid of vegetation cover, where did the fuel come from?

Table 4: Systematic relationship between calcrete stone size, shape, stain intensity and susceptibility. For photographic records see Figs 19-21, Ref. E.

SIZE	SHAPE	STAIN INTENSITY	SUSCEPTIBILITY
Large stones	High angular	Surface Shallow	0-10
Intermediate	Moderate angular	Deeper zoned	10-40
Small	Rounded	Throughout	40-70

SOUTH STACK ENIGMA

Several features of special interest lie on the surface of West Stack South (hereafter for simplicity, "South Stack") in juxtaposition over a small area. For the sake of brevity, and omitted from PRSV publications, two items in the centre of South Stack (Figure 6) add significantly to the possibility of human agency. Although subject to debate, the record is included here to stimulate discussion.



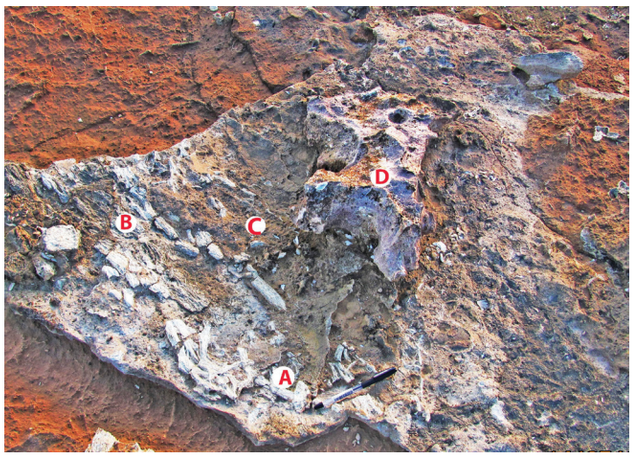
Above:

Figure 6: Geomorphic features of South Stack erosion surface (see Fig. 3).

S/T: pinkish pedogenically altered calcarenite limestone of Units S & T.

Rcp: thin mantle of Unit R groundwater calcrete with pothole and erosion pits into underlying S/T units. Dotted segments define traces of Z-event transported shell fragments.

Boxed Y area: site of (?) wood and limestone erratic, as per Fig. 7.



Right:

Figure 7: Photo of boxed area, Fig. 6.

(A) Elongate, closely fractured calcrete rods and branched structures lie in disarray on Unit R calcrete.

(B) More filamentous forms closely associated with mantle of cementing fluidised debris of Z-event (C).

(D) Large irregular block of eroded microcrystalline limestone containing cemented marine shell fragments. Lithologically distinct from exposed limestones, the selection, mode of transport and location of this strange block points suspiciously to deliberate intent.

Both items, the calcrete (possibly wood or transported rhizomorphs) together with limestone block are foreign to the site, both had to be imported. For details see text.

Firstly, resting on thin Unit R calcrete mantle, an assemblage of elongate calcified organic material resembles original wood structures (Figure 7). Secondly, a large block of pinkish limestone rests on the adjacent erosion surface.

Both items are foreign to the environment on which they rest.

Wood: A complex assemblage of linear, elongate branching forms, some round in section have been converted throughout by secondary carbonate. Parallel grain in jumbled branching forms identify as calcareous replacement of original organic structures. Frequently 3-15mm wide, these features carry closely spaced multiple fractures forming small 5-20cm lengths. The broken assemblage has been over-printed, sometimes buried by fluidised debris of Z-event matrix. Some fractures have been slightly displaced by debris, indicating fracture before that seismic event.

Entirely foreign to the marine abraded complex, these features require transport as large branched structures, broken on the calcrete surface and masked by Z-debris before burial by Unit Q aeolianite. Subsequent calcite replacement of organic structures has completed their formation before exposure by current high sea-level.

The combination of fine-grained structures and elongate and branching forms (Figure 7 A & B) suggest a primary vegetative origin. The close spacing of rod-like segments suggests a brittle material while the close spacing itself requires substantial force to produce such breaks; apparently while in position and without major disturbance. It suggests heavy impact.

While close timing with the seismic event might suggest a cause and effect relationship, the sequence requires that fractures were in place and only slightly moved when that event struck. The identity of original material requires clarification. Was it wood or some very complex arrangement of rhizomorphs?

Of the many rhizomorphs I have observed in calcareous soils throughout Australia, none bear any similarity to these features. Moreover, they lie here on an erosion surface fractured and masked by Z-debris, features inconsistent with soil rhizomorphs. The import and subsequent calcification of brittle wood remains the preferred interpretation.

Erratic Limestone: Perched precariously near the centre of South Stack (Figures 6 & 7) a block of pinkish, dense microcrystalline limestone (dimensions approx. 17x35x15 cm, weight approx. 25kg) rests beside the suspected wood complex. Unlike the composition of underlying calcarenite, Units S and T, irregular chemical etching reveals an internal assemblage of marine shell fragments. The absence of any surface abrasion testifies to its import onto this erosion surface by a mechanism beyond natural transport and depositional processes. Its matching lithologic source remains to be identified.

DISCUSSION

The original evidence based on shells is now greatly enlarged. Abundant examples of fire exist both before and after the Z-event, extending from stack onto the headland erosion surface. They represent important extensions through time and space.

The additional evidence of patterns preserved in erosion surface stones, the correlation between variability in size and shape with fire evidence, the occurrence of balanced stones (many in wrong places), all add considerably to surface complexity. These factors alone are sufficient to rule out accidental or coincidental natural phenomena. Any current explanation lies beyond natural agency.

The ages have been verified by three independent processes as last interglacial, but the reliability of human agency remains open to question. As one with a commitment to the geological (as distinct from specifically archaeological) evidence, I offer in sequence brief comments on the data sets involved.

1. Shells: As edible species only, they demonstrate a high degree of selectivity. Although the agency of birds cannot be eliminated, especially for Turbo shells, that explanation remains unlikely considering the diversity of limpets, abalone and Mulloway otolith (Sherwood, Ref. C). The association on West Stack with darkened, fire affected stones implies synchronous activity, shell collecting and fire.

The accumulation of shells on the top of that former marine abrasion surface implies a small fall in sea level from the time of surface cover to a lower level, permitting the collection and deposition of shell on the formerly high abrasion zone, a potential anvil site if deposited by birds.

2. Age convergence: To find the age of sea level, the age of dune accretion and fire all in synchronous relationship is one thing. To find the presence of collected edible shells associated with them is quite another. An agency other than pure chance demands explanation. The association of fire expands that option.

3. Fire: The initial discovery of definitive fire evidence, Fp1 (Figure 4) and its subsequent excavation (McNiven's Ref. F) reveal multiple darkening of stones, with spatial separation patterns suggesting repetitive burning at that site. Stone movement was involved in its formation after the Z-event. During that high energy event initial depressions were overprinted by debris displacement. This fire site was not in a natural depression. A second

fire site I recorded in 2016 (Fp2, Ref. E), is currently being excavated. Multiple fires through time on a surface without plants, both then as now, defies natural explanation.

4. Stone patterning: Correlative size, shape and colour involves a patterned evolution over time on a single erosion surface. It involved progressive blackening towards small, rounded black stones as end products of frequent fire practice. Additionally, movement of stones, some balanced on top of others (Figures 4 & 5A, also 10D in Ref. B) reflect processes inconsistent with natural deposition. This pattern maintained through time, both before and after Z-event interruption and across both stack and platform, requires explanation.

5. South Stack enigma: The several items of specific importance on South Stack involve details of both suspected wood and erratic limestone block (Figures 6 & 7).

In terms of the calcified organic material, the pattern of multiple fractures and timing with respect to the Z-event are particularly relevant. Its branching structures and elongate grain textures reflect the presence of woody structures. Severe fractures were later invaded, and partially covered by fluidised debris of the Z-event.

Two options are available, imported dry wood branches or imported rhizomorphs. While my colleague Dr. Steve Carey (pers. comm.) would favour the latter, the transport, fracturing and preservation of rhizomorph concretions on this bare rock surface is considered unlikely. The alternative involves import of branched, probably brittle tree fragments, followed by smashing under high vertical impact immediately before burial by Z-event debris. Subsequent burial and calcification transformed branched structures to the features uncovered by present erosion.

The adjacent limestone block presents a different picture. Deposited as a single entity, and lithologically unlike that on which it rests, this feature has been transported with no trace of transport medium. It rests as an erratic in form and mode of movement. It defies any mode of natural transport. Together with the adjacent calcified organic forms, both require to be imported. No natural process can be identified. Once more, human agency offers an answer.

6. Sea-level problem: Many will justifiably question the validity of these details for doubling the time of human occupation. The high sea-level environment is unlikely to be a time of arrival. Any ocean crossing passage from northern neighbours would favour a sea level, closer to 135ka, the previous MIS6 glacial stage. Unlikely as it seems, others have already postulated similar evidence.

7. Earlier interglacial occupancy: The possibility of human fires of comparable 120ka antiquity has been identified from charcoal peaks associated with sustained vegetation changes in pollen cores at several different localities. Initial evidence came from Lake George (Singh and Geissler,1985) and was followed by that from the marine record of ODP 820 off the northeast Queensland coast (Kershaw, et al., 1993). In a later synthesis of possible human impact in a number of pollen and charcoal records from marine and terrestrial cores in the northern Australian region, Kershaw et al. (2006) identify regional human impacts from about 45ka, about 68ka and perhaps into eastern Australia generally around 120-130ka.

Such evidence thus far has been given scant credibility by the archaeological community. The evidence presented here not only re-awakens those hypotheses but, in so doing, it offers ongoing accessibility to sceptics. Subject to traditional owners' approval, the Moyjil site remains available for on-site inspection. It awaits further research, the results of which will obviously test the validity of interpretations offered here. Some research is already in progress.

DISCUSSION SUMMARY

This brief account of main data sets may be reduced to items in simplified justification of my conviction:

- Shells, edible only, involves high degree of selection
- Multiple small fires, the same age as shells
- Fp1 site excavated reflects ordering, is not a natural depression
- Repetitive fires on bare rock, no vegetation on site at that time. Requires import of fuel.
- Suspected wood assemblage on South Stack with shells, not rhizomorph
- Clear selection of stones in fire sites, reuse of small black examples
- Susceptibility signals exactly follow correlative shape-colour intensity pattern. All small black stones are legacy of fire. Their location is essentially ordered.
- Organization of different stones, some older balanced over younger
- Large (25kg ?) erratic limestone boulder perched precariously on South Stack. Requires transport onto shell band. No natural process is possible.
- Boulder lies beside suspected "wood" with broken shell at 120ka.

CONCLUSION

Despite the absence of stone tools, food remains or other more specific items of humanity, the application of Ockham's Razor principle provides firm conviction. This is a case where one and only one explanation explains all.

In pursuit to disprove Edmund Gill's original human agency hypothesis, we have come full circle. People were present on the southern Victorian coastline at a time, now defined as 120,000 years ago. Following a slight decline of maximum sea-level at +8 m, people occupied rock platforms at the +6m level time until shoreline retreat permitted burial by 120ka dune accretion.

Having returned once more to much the same height as previous interglacials, the present sea level has revealed to Australia a slice of history beyond previous levels of imagination. With profound implications lying far beyond the limits of this summary, the significance remains to challenge this and future generations.

ACKNOWLEDGEMENTS

I am indebted to colleagues Steve Carey, Ian McNiven and especially John Sherwood for his years of patient and generous assistance. Although all have contributed substantially to the data presented here, I take full responsibility for the interpretations offered. This work was undertaken in collaboration with the Eastern Maar Aboriginal Corporation, Gunditj Mirring Traditional Owners Aboriginal Corporation and Kuuyang Maar Aboriginal Corporation. Helpful comments from Prof. Peter Kershaw and Prof. Robert Wasson improved this presentation. The late Professor John Prescott contributed substantially to dating in the early project stages. Although colleagues retain different levels of conviction, none thus far have offered other than minor differences of interpretation.

Despite a dire warning that "No archaeologist will believe you", the risk of encouraging scandal is more than off-set by the need to challenge disbelief.

BIBLIOGRAPHY PRSV

A. Sherwood J.E., (2018). The Moyjil site, south-west Victoria, Australia: prologue — of people, birds, shell and fire. *Proceedings of the Royal Society of Victoria, 130(2): 7-13.*

B. Carey, S.P., Sherwood, J.E., Kay, M., McNiven, I.J., Bowler, J.M., (2018). The Moyjil site, south-west Victoria, Australia: stratigraphic and geomorphological context. *Proceedings of the Royal Society of Victoria, 130(2): 14-31.*

C. Sherwood, J.E., Bowler, J.M., Carey, S.P., Hellstrom, J., McNiven, I.J., Murray-Wallace, C.V., Prescott, J.R., Questiaux, D.G., Spooner, N.A., Williams, F.M., Woodhead, J.D., (2018b). The Moyjil site, south-west Victoria, Australia: chronology. *Proceedings of the Royal Society of Victoria, 130(2): 32-49.*

D. Sherwood, J.E., McNiven, I. J., Laurenson, L., (2018a). The Moyjil site, south-west Victoria, Australia: shells as evidence of the deposit's origin *Proceedings of the Royal Society of Victoria, 130(2): 50-70.*

E. Bowler, J.M., Price, D.P., Sherwood, J.E.,Carey, S.P., (2018). The Moyjil site, south-west Victoria, Australia: fire and environment in a 120,000-year coastal midden— nature or people? *Proceedings of the Royal Society of Victoria, 130(2): 71-93.*

F. McNiven, I.J., Crouch, J., Bowler, J., Sherwood, J., Dolby, N., Dunn, J.E.,Stanisic, J., (2018). The Moyjil site, southwest Victoria, Australia: excavation of a last interglacial charcoal and burnt stone feature: is it a hearth? *Proceedings of the Royal Society of Victoria, 130(2): 94-116.*

REFERENCES

Clarkson, C., Jacobs, Z., Marwick, B., Fullagar, R., Wallis, L., Smith, M., Roberts, R.G., Hayes, E., Lowe, K.,Carah, X., Florin, S.A., McNeil, J., Cox, D., Arnold, L.J., Hua, Q., Huntley, J., Brand, H.E.A., Manne, T., Fairbairn, A., Shulmeister, J., Lyle, L., Salinas, M., Page, M., Connell, K., Park, G., Norman, K., Murphy, T. Pardoe, C., (2017). Human occupation of northern Australia by 65,000 years ago. *Nature,* 547: 306–310.

Fullagar, R.L.K., Price, D.M., Head, L.M., (1996). Early human occupation of northern Australia: archaeology and thermoluminescence dating of Jinmium rock-shelter, Northern Territory. *Antiquity* 70:751–773.

Hearty, P.J., Hollin, J.T., Neumann, A.C., O'Leary, M.J., McCulloch, M., (2007). Global sea-level fluctuations during the Last Interglacial (MIS 5e). *Quaternary Science Reviews* 26: 2090–2112.

Kershaw, A.P., McKenzie, G.M., McMinn, A., (1993). A Quaternary vegetation history of northeastern Queensland from pollen analysis of ODP site 820. *Proc. ODP, Sci. Results* 133:107–114.

Kershaw, P., van der Kaars, S., Moss, P., Opdyke, B., Guichard, F., Rule, S., Turney, C., (2006). Environmental change and the arrival of people in the Australian region. *Before Farming* 1: 1-24.

Nair, H., Sherwood, J., (2007). An unusual shell deposit at Point Ritchie, Warrnambool, Victoria: predator midden or natural shell deposit? *Proceedings of the Royal Society of Victoria* 119(1): 69–86.

Reeckmann, S.A., Gill, E.D., (1981). Rates of vadose diagenesis in Quaternary dune and shallow marine calcarenites, Warrnambool, Victoria, Australia. *Sedimentary Geology* 30: 157–172.

Sherwood, J., Oyston, B., Kershaw, A.P., (2004). The age and contemporary environments of Tower Hill Volcano, southwest Victoria, Australia. *Proceedings of the Royal Society of Victoria* 116: 69–76.

Singh, G., Geissler, E.A., (1985). Late Cainozoic history of fire, lake levels and climate at Lake George, New South Wales, Australia. *Philos. Trans. R. Soc. London* 311: 379–447.

NOTE: PDF copies of these papers available on request

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THESIS ABSTRACT

THE SANDS OF TIME: A LONG TERM RECORD OF COASTAL DUNE FORMATION AND EVOLUTION AT THE COOLOOLA SAND MASS.

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The coastal dune archives of SE Queensland represent one of the largest, oldest and most complex dune field systems on Earth. They are also a unique archive of change in the sub-tropics, an area under-represented in the paleoenvironmental literature. Of these dune fields, the Cooloola Sand Mass (240 km) is known to contain an exceptionally complete archive of dune activation and is world renowned for its podzol soil sequence and primary succession sequence. These made it a prime target for investigation.

This thesis presents a new optically stimulated luminescence chronology for the Cooloola Sand Mass. This is supported by morphological mapping of the dune field, limited ground penetrating radar surveys and stratigraphic logging of cliff sections.

In total, 52 OSL dates were obtained that span the middle Pleistocene to the latest Holocene. An extensive auger transect was undertaken across the dune field and the cliff exposure along Rainbow Beach was logged in detail.

Younger dune activity was investigated at Carlo Sand Blow. Repeated Late-Holocene reactivations were recognised. Dune activity was shown to be largely driven by fire events and in this landscape the fires are likely to relate to aboriginal occupation. The importance of fire for the reactivation of a single blow-out contrasts with the primary role of sea-level change in driving wider dune field activations and emphasises the importance of scale in dune studies.

Morphological mapping of the dune sequences was conducted to identify and delineate the major periods of dune building in the dune field. This high-resolution LiDAR based mapping involved classification of dunes using morphometric characteristics and allowed for a better resolved dune field map than was possible with older technologies. Nine phases of dune building that has occurred periodically since the middle Pleistocene. Five Holocene and four Pleistocene phases were recognised. The OSL dating identified distinct periods of activity at ca. 800 ka, 140 –150 ka, 110 – 120 ka, 10-6 ka, 5-3.5 ka, 2.4-1.9 ka and 0.4-0.2 ka. Late Pleistocene (Marine Isotope Stage 5) and Holocene dune activity coincides with post-glacial marine transgressions which is consistent with dune formation during rising sea levels. This evidence strongly supports the Cooper-Thom hypothesis of coastal dune formation, which focuses on sediment release due to shoreface erosion during rising sea-levels.

A stratigraphical and geochronological investigation was also conducted along the Rainbow Beach cliffs. The results of this investigation produced the oldest OSL ages from the Cooloola Sand Mass ever recorded. The earliest period of dune activity at Cooloola was dated to >900 ka, with magnetostratigraphy used on novel target materials to confirm the OSL chronology. The earliest phases of dune activity at the Cooloola Sand Mass were very different to the late Pleistocene dune fields. The latter were dominated by parabolic dunes whereas the former represent a set of transgressive sheets. This earlier style is attributed to a massive influx of sand to the modern dune field when enhanced sea-level change at the Middle Pleistocene Transition (MPT), released sediment stored off shore and drowned the coastal lowlands in sand. The MPT is widely recorded in marine records but the formation of the Cooloola Sand Mass is a unique and world class terrestrial archive of the geomorphic impact of the MPT.

This thesis has substantially advanced the understanding of the formation of coastal dune fields in eastern Australia and the findings are likely to be widely applicable in passive margin settings worldwide. It has also provided new information about the Cooloola Sand Mass, which should assist in the nomination of the dune field as a new World Heritage Area. It is hoped that the mapping and chronology can re-invigorate coastal dune research in Australia.

BOOK REVIEW

A Memory of Ice

Elizabeth Truswell

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https://press.anu.edu.au/publications/memory-ice

Reviewed by Helen Bostock

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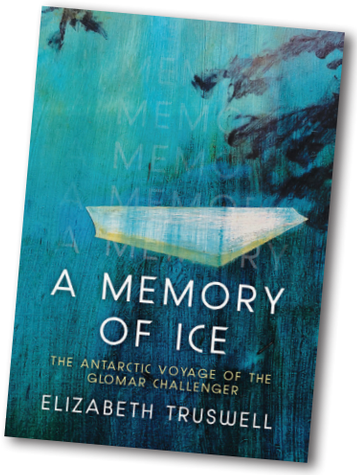


"During the voyage, in the best tradition of Antarctic explorers, I kept a diary....these many years later it is tattered and barely legible. It records the daily activity associated with drilling, the anticipation of steaming to new sites - to unsignposted spots in a blank grey ocean - the nervous waiting for cores to come up, the frenzy of activity when they do, the late night discussions around the science, and always the weather and the wildlife." Elizabeth Truswell.

This book is the story of Antarctic palynologist Elizabeth Truswell's experience of participating on the Deep Sea Drilling Project (DSDP); Leg 28 to Antarctica. The book is a narrative of the Leg 28 expedition sourced from Liz's diaries and memory. It is woven with the history of voyages of scientific exploration: From the James Cook and HMS Challenger expedition to the early expeditions to Antarctica by the French, US and British looking for the southern landmass. Fame and national pride are inextricably part of the fabric of the narritave. Liz was one of several Australians and New Zealanders that were part of the expedition; including Peter Barrett (sedimentologist), Peter Webb (foraminifera), Derek Burns (nannofossils). The book was launched at the International Conference on Paleoceanography (ICP) at UNSW in Sydney in September 2019. It was introduced by Leanne Armand from ANZIC International Ocean Discovery Program (IODP) office, along with the presentation of a short movie from the expedition, made by Peter Barrett (who was also present at the book launch) and some highlights from the recent Ross Sea expedition by co-chief Rob McKay. Excerpts from the book were read by Liz.

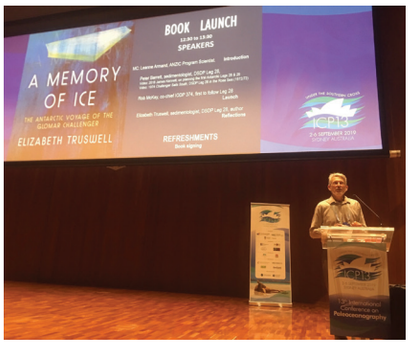
As well as trying to explain how and why we do deep sea coring for a general audience, the book centres around Liz's life long quest to try to understand the history of Antarctica's vegetation.

This story started with the early work of New Zealand's Lucy Cranwell, a pioneer of palynology, who found *Nothofagus* (beech) pollen from boulders on Seymour Island and the Ross Sea. This pollen evidence suggested there had been extensive forests on Antarctica. Leg 28 contributed significantly to this story, specifically DSDP Site 270. The book brings together the story of Antarctica's vegetation and glacial history from Leg 28 and a number of subsequent DSDP, ODP and IODP expeditions to Prydz Bay, Wilkes Land and the Ross and Weddell Seas over the last 50 years of deep sea drilling.

Prior to Leg 28, the ice sheets of Antarctica were assumed to be the same age as those in the Northern Hemisphere, approximately 3 Ma. This expedition pushed the onset of glaciation in Antarctica back to about 25 Ma.

More recent work has shown this onset of glaciation was even earlier, now thought to be at the Eocene/Oligocene boundary (34 Ma), even though plants remained present and relatively diverse up to the mid Miocene, suggesting that glaciation was gradual and the extent of glaciation varied spatially. Few plants survived the Pliocene through to today.

Liz is a trailblazer, being one of the first women scientists to go on these early ocean drilling expeditions. She was a great role model for me during my PhD, in a department with few senior females. While she is clearly more comfortable writing about the history, there are a few comments that provide some personal insight into her experiences on that voyage, with comments about her colleagues strong personalities. I look forward to sitting down with her over a glass of wine and finding out more about what really went on during the expedition.



Photos from the book launch 'A Memory of Ice' at ICP13, 2-6 September, Sydney.

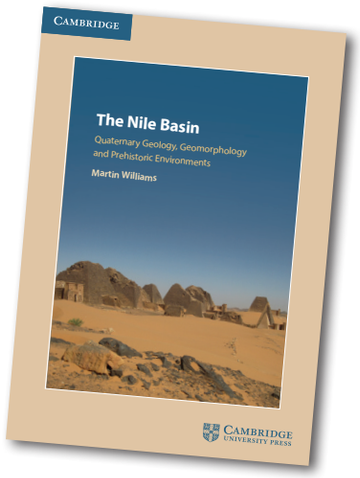
Figure 1: Peter Barrett

Figure 2: Rob McKay

Figure 3: Elizabeth Truscott

All Photo credits: Helen Bostock.

The Nile Basin: Quaternary Geology, Geomorphology, and Prehistoric Environments



Martin Williams

Cambridge University Press.

Hardback, xi + 405pp ISBN 978-1-107-17919-6

Reviewed by W. Boone Law

University of Adelaide, South Australia.

Archaeologists are rarely equipped with the expert knowledge necessary to interpret the landscape weathering processes and climate dynamics that affected the prehistoric environments occupied by ancient peoples. This task belongs to the realm of the Earth sciences, where geologists, geomorphologists, and climate scientists concern themselves with collecting and processing data that improve our depiction of ancient environmental changes. One of the best at this game is Emeritus Professor Martin Williams (University of Adelaide), a preeminent world authority on the geomorphology of arid and semi-arid landscapes. He is a widely published and influential researcher, contributing to more than 200 scholarly articles and a dozen books. Over his six-decade career, he has collaborated with a multitude of geologists, geomorphologists, archaeologists, climate scientists and earth scientists, notably in northern Africa, China and Australia. The contributions he has made to our understanding of global climatic and environmental change are immense, and his work is renowned in Quaternary science circles. He is a thoughtful and meticulous field researcher, as illustrated in his recent memoir, *Nile Waters, Saharan Sands: Adventures of Geomorphologist at Large* (Williams 2016). If you have not yet read *Nile Waters, Saharan Sands*, I recommend it as an engaging personal account of Williams' approach to fieldwork and how he integrates his talents for prehistoric environmental reconstruction with the many disciplines of Quaternary science.

His most recent book, *The Nile Basin: Quaternary Geology, Geomorphology, and Prehistoric Environments* (Williams 2019), is a natural follow-up to his 2016 memoir. The book is more academic in tone, but it aims to present the subject matter in a way that is accessible to hard-core researchers, students, and avocationalists alike. The first two chapters introduce the reader to the Nile Basin (Chapter 1) and discuss the evolution the basin in the context of its age, erosion, and tectonic history (Chapter 2). These chapters are important for establishing the readers understanding of the geography of the region. The next three chapters build on this baseline knowledge with a synthesis of the Nile basin's climate and hydrology (Chapter 3), geology and soils (Chapter 4), and vegetation, land use and human impacts (Chapter 5). This background information is stock standard for academic studies of this nature, but it is an important foundation for familiarising the reader with the large and diverse physiographic regions of North Africa. I particularly enjoyed these

chapters because Williams has a knack for breaking down complex Earth science and geomorphic processes into a language that is engaging to read. From here, the next 15 chapters dive into the evolution of the Nile Basin, following the pathway of sedimentation from the river's mountainous headwaters to the Nile Delta; 6800 km north. This "Source to Sink" narrative approach, as Williams calls it, geographically breaks the basin into physical regions, beginning with the Nile's headwaters in Chapter 6-9 and its' upper tributaries in Chapters 10-12. On a region-by-region basis, Williams neatly lays out how prehistoric environments can be reconstructed, introducing connections to archaeological patterns along the way.

As Williams 'tours' us along the Nile Basin, he periodically pauses to provide chapter-length accounts of more peripheral regions such as the Jebel Marra Volcano (Chapter 13), the Desert Nile in Egypt (Chapter 14), the Western Desert of Egypt (Chapters 15 and 16), the Fayum (Chapter 17), the Red Sea Hills (Chapter 18), and the Sinai Desert (Chapter 19). It is an effective narrative strategy, naturally leading the reader to the mighty river's mouth and culminating in chapters on the Nile Delta (Chapter 20) and Nile Cone (Chapter 21). It is at this point that Williams turns his focus to directly incorporating and interpreting the archaeological record that he has casually introduced throughout the book. Archaeologists will undoubtedly be interested in how he ties prehistoric environmental changes with our understanding of the origins of plant and animal domestication in the Nile basin (Chapter 22) and how this information relates to models of prehistoric subsistence and settlement for roughly the past 12,000 years. Williams concludes his book by diving much deeper into human prehistory, with a discussion of migration routes traversed by early hominins as they spread 'Out of Africa' (Chapter 23).

The depth of knowledge conveyed in this work is impressive and the well-explained sedimentary and environmental history is intertwined with carefully considered quotations from scholars, explorers, and historic figures who, like Williams, have pondered the forces of nature that formed the basin. Having never read 5th century BC historian Herodotus myself (whom Williams cites on many occasions), I was consistently impressed by Herodotus' keen observational skills on the structure of the Nile Basin, which are thoughtful and accurate some 2500 years later.

Although I found the geomorphology and prehistory of the Nile Basin fascinating, I read this book from the perspective of an Australian archaeologist (my professional background), looking for similarities we can use to interpret the ancient Aboriginal archaeological record. Williams has worked in many arid regions of the world, but Australia has been his home for most of his life. Where appropriate, he often cites comparable Australian research, and it is clear that his Australian field experiences have influenced his Nile Basin work, like his work in the northern Flinders Ranges for example (Williams et al. 2001, Williams et al. 2006). From my perspective, there is much in this book that may be viewed as an analogue for areas of arid and semi-arid Australia, especially his descriptions of geomorphological processes that can affect archaeological site formation (e.g. stony pavement development, shoreline fluctuations of palaeolakes, and bioturbation of archaeological deposits). He additionally provides helpful examples of the kinds of field information required to reconstruct the prehistoric environmental record, which is useful to consider with fieldwork preparation (see Chapter 4). In his discussion of prehistoric environments, it is clear that past climatic events that affected the aridity and water availability in the Nile Basin are, in general, globally analogous to the timing of palaeoclimatic events that affected Aboriginal subsistence in the Australian arid zone (e.g. hyperaridity at the last glacial maximum, terminal Pleistocene return of monsoon rain cycles, and increased mid-Holocene aridity). Thus, although his subject matter is foreign, serious Australian archaeologists will find his depiction of how prehistoric populations responded to increased aridity and environmental change naturally relatable. I suspect this would also be the case for researchers working in arid regions of Asia, especially in the desertic areas of northern China and southern Mongolia.

For me, 'Chapter 22: Origins of Plant and Animal Domestication in the Nile Basin', is the most satisfying part of the book. This penultimate chapter is where Williams ties the geology, geomorphology, and prehistoric environments of the Nile Basin together to critically assess why the transition from a 'Mesolithic' hunter-fisher-gatherer economy to a 'Neolithic' agricultural economy occurs later in the Nile Basin than in adjacent areas to the northeast, such as the Fertile Crescent of the Levant and Anatolia. The 'Neolithic' archaeological signature of the Nile Basin emerges ca. 8-7 ka, several thousand years after the agriculture and animal domestication was established in the Fertile Crescent (ca. 11-10 ka). His answer to this question is not simplistic or straightforward and Williams (2018: 321) aptly warns that "we should always remain sceptical of over-simplified single

cause explanations, however elegantly expressed." Using the Quaternary history of the Nile Basin, Williams clearly illustrates how the transition to agriculture (or in the least, nomadic pastoralism) is variable, occurring at different times in areas of the basin. He outlines several models that have been proposed to explain how and why 'Neolithic' economies emerged, but he highlights that much more work is required to properly test the underlying hypotheses of these models. Of importance, Williams notes that the prospect of environmental change as the catalyst for prehistoric demographic change can be difficult to see in the archaeological record, as the interaction between the environment and society is complex and often unclear. In his assessment of the transition from hunter-fisher-gatherer societies to more sedentary agricultural economies, Williams (2019: 321) states "It is a truism to say that when confronted with extreme environmental catastrophes (the form sometimes but not invariably associated with abrupt climatic changes), human societies can opt to migrate, can seek to adapt, or can become extinct. The progressive move from Mesolithic to Neolithic in the Nile basin doubtless encompassed elements of all three responses." Although he speaks to a North African context, I believe this assertion should resonate with researchers of Australian arid zone archaeology, especially in regard to the manner that ancient Aboriginal populations responded to the hyperarid conditions during last glacial maximum.

Williams turns his attention to early Hominin migrations 'Out of Africa' into Eurasia in the epilogue of *The Nile Basin*. This final chapter provides a good overview of the key sites, themes, and timing of 'Out of Africa' migrations for *Homo ergaster*, *Homo erectus*, and *Homo sapiens*. I found this chapter informative, but it only scratches the surface on this dense and voluminous subject. I get the feeling that Williams is only warming up on his knowledge of this material but, as he states in the preface of the book, he will only review some themes in sufficient detail to answer the questions raised. Thus, if this chapter was concerned with the movements of early hominins 'Out of Africa,' then I believe the subject was adequately addressed. However, out of personal interest, I wanted a bit more.

The most challenging task in reading this book was my unfamiliarity with the geography of North Africa. Williams provides clear maps and figures to guide you throughout, but I found myself continually revisiting earlier chapters to refamiliarize myself with the geography. As I progressed further into the book, my need to revisit earlier maps decreased, but I did at times wish for there to be a master location map that was more easily accessible, perhaps immediately inside the front or back cover. However, this criticism is trivial, on what is otherwise as high-quality book production by Cambridge University Press.

Aside from being an exemplary geomorphologist, Williams is a master writer and scientific communicator. For an academic text, I found *The Nile Basin* to be highly readable, with well-designed black and white figures, tables, and photographs throughout. It is clearly aimed at readers who know very little about the geography or environmental history of the Nile, but perhaps have just enough knowledge of the region to 'get themselves into trouble.' Overall, *The Nile Basin* is a well-organised work, and one never feels too intimidated with the potentially overwhelming content, as each chapter is succinctly summarised at its conclusion. Moreover, the handy index ensures that you never get lost in terminology.

In short, this book makes me yearn to travel to North Africa and learn more about this amazing ancient river basin. I recommend it as a reference for students and professional geomorphologists interested in arid and semi-arid geoarchaeological themes, and I believe it is an essential read for all Quaternary researchers working in the Nile Basin and adjacent areas of North Africa.

REFERENCES

Williams, M., (2016). Nile Water, Saharan Sands: Adventures of a Geomorphologist at Large. *Springer International Publishing*. AG, Cham, Switzerland.

Williams, M., (2019). The Nile Basin: Quaternary Geology, Geomorphology, and Prehistoric Environments. *Cambridge University Press*. Cambridge, United Kingdom.

Williams, M., Nitschke, N., Chor, C., (2006). Complex geomorphic response to late Pleistocene climatic changes in the arid Flinders Ranges of South Australia. *Géomorphologie: relief, processus, environnement*, *12*(4):249-258.

Williams, M., Prescott, J.R., Chappell, J., Adamson, D., Cock, B., Walker, K., Gell, P., (2001). The enigma of a late Pleistocene wetland in the Flinders Ranges, South Australia. *Quaternary International*, *83*:129-144.

UPCOMING MEETINGS

JANUARY 2020

Data and Methods in Paleo Proxies Sciences Workshops
Venue: Da Lat, Vietnam
Date: 6-12 January, 2020

Hokudan 2020 International Symposium on Active Faulting
Venue: Hokudan, Awaji City, Awaji Island, Japan.
Date: 13-17 January, 2020

6th International Palaeoflood Conference
Venue: Palmerston North, New Zealand
Date: 29-31 January, 2020

FEBRUARY 2020

Ocean Sciences Meeting 2020
Venue: San Diego, CA, USA
Date: 16-21 February,2020

Demystifying the IODP Proposal Process for Early Career Scientists: Pacific Ocean
Venue: Palisades, NY, USA
Date: 17 -20 February, 2020

World Biodiversity Forum 2020
Venue: Davos, Switzerland
Date: 23-28 February, 2020

MARCH 2020

LandCover6k 4th General Workshop: New Land-Cover and Land-Use Datasets for evaluation and improvement of Anthropogenic Land-Cover Change Scenarios
Venue: Philadelphia, PA, USA
Date: 1-6 March, 2020

36th International Geological Congress
Venue: Delhi, India
Date: 2-8 March, 2020

APRIL 2020

Distinguishing Storm and Tsunami Deposits
Venue: Flagstaff, AZ, USA
Date: 26 April, 2020

SEPM International Sedimentary Geosciences Congress
Venue: Flagstaff, AZ
Date: 26-29 April, 2020

SSA Annual Meeting
Venue: Albuquerque, NM
Date: 27-30 April, 2020

MAY 2020

EGU General Assembly 2020
Venue: Vienna, Austria
Date: 3-8 May, 2020

5th IMERP
Venue: Naujoji Akmene, Lithuania
Date: 18-21 May, 2020

Cities on Volcanoes 11 Conference
Venue: Heraklion, Crete, Greece
Date: 23 -27 May, 2020

JUNE 2020

Beyond Palaeoclimate Ping Pong: Improving estimates of past climate variability by consistent data-model comparison
Venue: Heidelberg, Germany
Date: 2-5 June, 2020

Centenary Palaeoecology Symposium - From the past to the future: 100 years of Palaeoecology in Bern
Venue: Bern, Switzerland
Date: 8-10 June, 2020

Sustainability Research and Innovation 2020
Venue: Brisbane, Australia
Date: 14 -17 June, 2020

2nd International Conference on Contaminated Sediments
Venue: Bern, Switzerland
Date: 14-18 June, 2020

PMIP meeting
Venue: Nanjing, China
Date: 22-26 June, 2020

35th IAS meeting
Venue: Prague, Czech Republic
Date: 23-26 June, 2020

JULY 2020

14th International Coral Reef Symposium
Venue: Bremen, Germany
Date: 5-10 July, 2020

World Congress on Geology & Earth Science: GeoEarth2020
Venue: Osaka, Japan
Date: 9-11 July, 2020

Climate Change, The Karst Record (KR9 Conference)
Venue: Innsbruck, Austria
Date: 11-20 July, 2020

AQUA2020 Conference
Venue: Atherton Hotel, Atherton, Far North Queensland.
Date: 20 - 24 July 2020

https://aqua.org.au/conference

AUGUST 2020

19th International Swiss Climate Summer School
Venue: Grindelwald, Switzerland
Date: 23-28 July, 2020

SEPTEMBER 2020

37th General Assembly of the ESC
Venue: Corfu, Greece
Date: 6-11 September, 2020

3rd International Conference on Polar Climate and Environmental Change in the Last Millennium
Venue: Toruń, Poland
Date: 24-26 September, 2020

OCTOBER 2020

Ponto-Caspian Stratigraphy and Geochronology (POCAS)
Venue: Tehran, Iran
Date: 11-18 October, 2020

3rd IPICS Open Science Conference
Venue: Crans-Montana, Switzerland
Date: 18-23 October, 2020

NOVEMBER 2020

PATA Days 2020
Venue: Hornitios, Chile
Date: 8-12 November, 2020

PAGES-INQUA joint ECR workshop: Past Socio-Environmental Systems (PASES)
Venue: La Serena y Coquimbo, Chile
Date: 9-13 November, 2020

ADVANCE NOTICE

Palaeo Down Under 3
Venue: Brisbane
Date: 2020

XXI INQUA congress
Venue: Rome, Italy
Date: 13-20 July, 2023

CABAH
Venue: James Cook University, Cairns
Date: Details to come

RECENT PUBLICATIONS

Allan, R. J., Gergis, J., D'Arrigo, R. D., (2019). Placing the AD 2014–2016 'protracted' El Niño episode into a long-term context. The Holocene: doi: https://org/10.1177/0959683619875788

Bracegirdle, T. J., Colleoni, F., Abram, N.J., Bertler, N. A. N., Dixon, D. A., England, M., Favier, V., Fogwill, C.J., Fyfe, J.C., Goodwin, I., Goosse, H., Hobbs, W., Jones, J.M., Keller, E.D., Khan, A.L., Phipps, S.J., M.N., Raphael, Russell, J., Sime, L., Thomas, E.R., van den Broeke, M., Wainer, I., (2019). Back to the Future: Using Long-Term Observational and Paleo-Proxy Reconstructions to Improve Model Projections of Antarctic Climate. Geosciences, 9:255. doi: https://10.3390/geosciences9060255

Brönnimann, S., Allan, R., Ashcroft, L., Baer, S., Barriendos, M., Brázdil, R., Brugnara, Y., Brunet, M., Brunetti, M., Chimani, B., Cornes, R., Domínguez-Castro, F., Filipiak, J., Founda, D., Herrera, R. G., Gergis, J., Grab, S., Hannak, L., Huhtamaa, H., Jacobsen, K. S., Jones, P., Jourdain, S., Kiss, A., Lin, K. E., Lorrey, A., Lundstad, E., Luterbacher, J., Mauelshagen, F., Maugeri, M., Maughan, N., Moberg, A., Neukom, R., Nicholson, S., Noone, S., Nordli, Ø., Ólafsdóttir, K. B., Pearce, P. R., Pfister, L., Pribyl, K., Przybylak, R., Pudmenzky, C., Rasol, D., Reichenbach, D., Řezníčková, L., Rodrigo, F. S., Rohr, C., Skrynyk, O., Slonosky, V., Thorne, P., Valente, M. A., Vaquero, J. M., Westcottt, N. E., Williamson, F. and Wyszyński, P., (2019). Unlocking pre-1850 instrumental meteorological records: A global inventory. Bulletin of the American Meteorological Society:1-62. doi: https://org/10.1175/BAMS-D-19-0040.1

Fagg, R., Smalley, I., (2019). Loess in New Zealand: observations by Haast, Hutton, Hardcastle, Wild and Speight, 1878–1948. Quaternary International, 502: 173–178. doi: https://dx.doi.org/10.1016/j.quaint.2019.01.029

Hogg, A.G., Wilson, C.J.N., Lowe, D.J., Turney, C.S.M., White, P., Lorrey, A.M., Manning, S.W., Palmer, J.G., Bury, S., Brown, J., Southon, J., Petchey, F., (2019). Wiggle-match radiocarbon dating of the Taupo eruption. Nature Communications 10(1): 4669. https://doi.org/10.1038/s41467-019-12532-8

Karolyte, R., Johnson, G., Gyore, D., Serno, S., Flude, S., Stuart, F.M., Chivas, A.R., Boyce, A. and Gilfillan, S.M.V., (2019). Tracing the migration of mantle CO2 in gas fields and mineral water springs in south-east Australia using noble gas and stable isotopes. Geochimica Cosmochimica Acta, 259: 109-128. doi: https://doi.org/10.1016/j.gca.2019.06.002

Newnham, R.M., Hazell, Z.J., Charman, D.J., Lowe, D.J., Rees, A.B.H., Amesbury, M.J., Roland, T.P., Gehrels, M.J., van den Bos, V., Jara, I.A., (2019). Peat humification records from Restionaceae bogs in northern New Zealand as potential indicators of Holocene precipitation, seasonality, and ENSO. Quaternary Science Reviews, 218: 378-394.

Slivinski, L. C., Compo, G. P., Whitaker, J. S., Sardeshmukh, P. D., Giese, B. S., McColl, C., Allan, R., Yin, X., Vose, R., Titchner, H., Kennedy, J., Spencer, L. J., Ashcroft, L., Brönnimann, S., Brunet, M., Camuffo, D., Cornes, R., Cram, T. A., Crouthamel, R., Domínguez-Castro, F., Freeman, J. E., Gergis, J., Hawkins, E., Jones, P. D., Jourdain, S., Kaplan, A., Kubota, H., Le Blancq, F., Lee, T.-C., Lorrey, A., Luterbacher, J., Maugeri, M., Mock, C. J., Moore, G. W. K., Przybylak, R., Pudmenzky, C., Reason, C., Slonosky, V. C., Smith, C., Tinz, B., Trewin, B., Valente, M. A., Wang, X. L., Wilkinson, C., Wood, K. and Wyszyn'ski, P., (2019). Towards a more reliable historical reanalysis: Improvements for version 3 of the Twentieth Century Reanalysis system. Quarterly Journal of the Royal Meteorological Society: 1-33. doi: http://dx.doi.org/10.1002/qj.3598

Tuut, J-B. W., DeDeckker, P., Saavedra-Pellitero, M., Bassinot, F., Drury, A-J., Walczak, M.H., Nagashima, K., Murayama, M., (2019). A 5.3-million-year history of monsoonal precipitation in north-western Australia.Geophysical Research Letters 46: 6946–6954 (+ 13 pages supplement).

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