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Quaternary AUSTRALASIA

AQUA turns 30: a retrospective

Iconic sites of Australasia

Quaternary research alive and well in New Zealand

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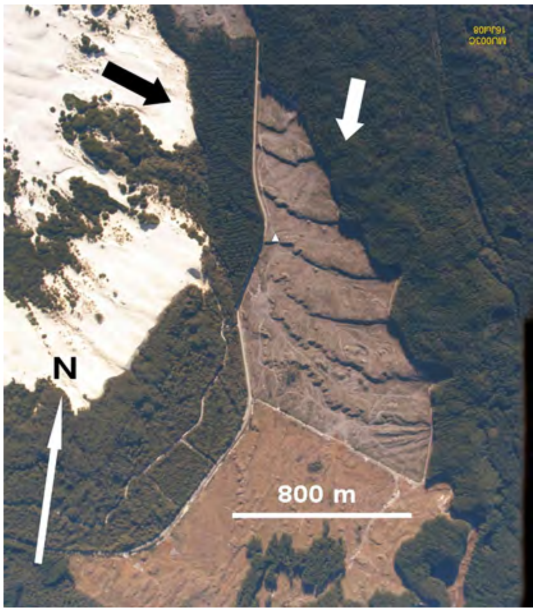

Cover Photo: Mount Picton (1327 m), in Tasmania's southwest, looking south-southwest from above Mt Riveaux. On the left (southeast aspect) are Lake Picton, Lake Riveaux and Glassworm Tarn, developed in glacial cirques, with the Cook Creek valley and the South Picton Range beyond them, and Precipitous Bluff (top left). On the right (north aspect) the undated Welcome Moraine, probably representing the maximum extent of ice in the LGM, is visible. Undated strongly weathered moraines in the lower Cook Creek valley, not obvious in this photograph, indicate the much larger extent of earlier glaciations. Under fog is the Cracroft Valley and beyond this Strike Ridge and Mount Hopetoun.
Photograph: Chris Bond (Forestry Tasmania)
Caption: Peter McIntosh (Forest Practices Authority) and Adrian Slee (University of Queensland)

Photo This Page: The transverse dune pattern south of the Henty River, Strahan, Tasmania, as revealed after pine harvest, apparently indicating winds from the north (white arrow) during dune formation. In contrast the presently active Henty Dunes (top left) are moved by winds from the westerly quarter (black arrow). A thermoluminescence age obtained from 2 m depth at the site marked by the triangle showed that the sands here accumulated 10.1+/-1.2 ka BP (analysis by David Price, University of Wollongong). The source of the sands forming the transverse dunes may have been the floodplains of the Henty and Tully Rivers 2 km to the north, but whether the seven dune fronts represent pulsating sediment supply or regular changes in wind strength is unknown. Plantation harvest and in particular machine use here was carefully controlled by Forest Practices Authority prescriptions, to ensure minimal damage to dune morphology.
Photograph: Joe Hawkes (Tasmania Land and Forests)
Caption: Peter McIntosh (Forest Practices Authority)

Editorial

Dear Fellow Quaternarists,

This year marks the 30th anniversary of the Australasian Quaternary Association, and of the first issues of Quaternary Australasia using its present name (although, as Eric Colhoun explains, the newsletter existed prior to 1982 – west of the Tasman – as the Australian Quaternary Newsletter). In honour of this occasion, and to encourage reflection on the changes our science and supporting Society have experienced over the years, we have prepared a special celebratory issue.

This issue contains not only research and conference reports, but also a number of articles designed to stimulate discussion among community members. Eric Colhoun, AQUA's first official President, provides an account of the association's humble and organic beginnings. Kat Fitzsimmons attempts to identify the Quaternary "icons" of our region; responses and rebuttals are certainly welcome in future issues! Our Vice-President, Helen Bostock, and Kiwi colleagues outline exciting developments made in NZ Quaternary research. Jessica Reeves updates us on the culmination of several years of the Australasian INTIMATE endeavour. We have updates from Stephanie Kermode, Judith van Dijk and Scott Sharp-Howard, and Joe Prebble on several events, workshops and conferences. Adrian Slee and colleagues reassess a well-known Quaternary deposit in Tasmania, and John Magee reviews Kirsty Douglas' recently published book. Finally, Jim Bowler pays tribute to Alan Thorne, who recently passed away.

The news section in this issue is more substantial than in previous volumes. In addition to a number of important notices, we thought you might appreciate getting to know members of the executive committee a little better! We will introduce a new office bearer with each subsequent issue.

In addition, we have included a centrefold spread of photos taken at various AQUA events over the years. We hope you enjoy recognising colleagues (and even yourselves!) and their changing fashions as you peruse this feature!

Yours Quaternarily
Kathryn Fitzsimmons and Jasmyn Lynch
Editors


President's Pen

I have been experiencing a strange sense of déjà vu over the past year or so, as I have been delving into the archives of Quaternary Australasia, and its predecessor, the Australian Quaternary Newsletter. From its first utterances as a collective of multi-disciplinary researchers who chose to define themselves by a period in time, there was a collegiate desire to bring together a shared respect for deep time and sense of place that characterises our science. However from the outset back in March 1973, the desire was not to be an international journal, but rather a "cooperative effort to publicise current activity". Perhaps a support group for the like-minded in a time when communication was not as immediate as it is these days?

With the formation of the Quaternary Association at the ANZAAS conference of May, 1982, things immediately got more political. The first issue of Quaternary Australasia was almost exclusively devoted to objection pieces to the Franklin Dam, including several submissions to parliament. A time when scientists were very much prepared to stand up for their beliefs and communicate them effectively to both government and the broader community.

Another great advance at this time was the series of CLIMANZ meetings, which looked to characterise the climate and environmental changes of Australasia through the Late Quaternary, bringing together the various proxies. In many ways, INTIMATE is the most recent incarnation of this project, with the advance of a few more sites and some more rigorous chronology.

Of course the Australasian Quaternary Association was not formally devised until the field meeting at the Grand Hotel in Mildura in July of 1985. We will be commemorating this event at our next biennial meeting in July of 2014.

I have enjoyed reading through the anecdotes shared by very familiar names when they were part of the AQUA committee and realise that we are following on from, and building onto, a great tradition. Long live AQUA. Happy anniversary!

Jessica Reeves
AQUA President

News

Introducing the new AQUA executive

Over the next few issues, we would like to introduce some of the new members of the AQUA executive. Hopefully in learning a bit more about us, you might be inspired to step up and join us.

Helen Bostock: Vice President and IT Co-ordinator

Helen is a paleoceanographer who did her PhD at The Australian National University on changes in the Southern Great Barrier Reef, and after a brief stint at Geoscience Australia in the coastal group has been working at the New Zealand National Institute of Water and Atmospheric Research in the Ocean Geology Group for the last 6 years. Her main area of interest is now the Southern Ocean and its influence on climate. She is a keen gardener and cook, and does a lot of tramping in New Zealand. She occasionally blogs about her adventures and, while she is not an IT expert, she has bravely taken on the role of the IT Co-ordinator.

Launch of new website

still at the same website address: www.aqua.org.au

After many years and lots of work put into the old website by Tim Barrows, it was starting to look a little dated and we decided it was time for a fresh look. Thanks to the efforts of Mohsen Rezaei, an IT student at the University of Ballarat, for putting in the hard yards of getting one set up and then a lot of time and effort spent by Helen Bostock transferring all the old material across to the new website. A considerable amount of time has also gone in to scanning all the Australian Quaternary Newsletters and Quaternary Australasia, many thanks to Rosie Grundell, and putting them up on line so that they are all available. So we hope you will find this archive useful. We have also put up pdf's of the abstract volumes from the recent AQUA conferences. If you have any of the older abstract volumes, we would love to hear from you and scan them and put them on the website for others to refer to. We are also looking for more photos to put up on the website of people doing field work, field trips, and meetings - to show that we are a dynamic and fun group.

Please take a look and let us know what you think! What else would you like to see on the website? Would you like a News page where we can put up press releases to peoples, work or papers?

For all of your comments and ideas, please contact Helen (Helen.Bostock@niwa.co.nz).

Online AQUA membership

You can also sign up and renew your membership online. There is a link on the membership page of the new AQUA website. It is easy, so please get yourself signed up and encourage your colleagues, students and friends. If, in the rare case you do have an issue with the online system, please contact our treasurer, Steven Phipps (s.phipps@unsw.edu.au).

AQUA's foray into social media

Yes, exciting times at AQUA. Along with the new website and online membership system, we are dragging AQUA into the 21st century, by dabbling in social media. We encourage you to sign up to the Australasian Quaternary Association (AQUA) facebook group (http://www.facebook.com/groups/43580401738/), where people can upload links to related organisations, as well as to news stories or jobs that are being advertised. This is also a forum for discussions or to comment on events. We hope that this will be a good starting point to encourage communication between Quaternary researchers (and students) and researchers from other related fields. This could be used in conjunction with the AQUAlist to get information out. If you have any queries or suggested contributions that you want to run by someone first, contact Craig Sloss (c.sloss@qut.edu.au).

Science Communication

The AQUA committee have also been discussing some ideas about communicating Quaternary science to a broader audience after the experience at Science meets Parliament (see article by Stephanie Kermode). We want to investigate how we can better engage with related fields of science, as well as the media and general public. We would like to start by asking for your experiences. Do you contribute to mainstream media? Do you engage with policy makers or government at state or federal level? Do you 'tweet' about your latest paper or other science matters? If you have any thoughts or experience on this we would love to hear from you and we hope to disseminate these ideas in the next QA.

As a first step, we are interested in recruiting a PhD student or early career researcher who is interested in blogging. Someone who is keen to review Quaternary papers, stories from their fieldwork, or conferences etc. We will link the blog to the AQUA website. If you are interested in this position, or you know someone who fits the bill, we'd love to hear from you.

For either of these, please contact Jessica (j.reeves@ballarat.edu.au) or Helen (Helen.Bostock@niwa.co.nz).

Inaugural INQUA ECR meeting

The plans are in motion for the first INQUA ECR meeting, which will be held in Australia in November, 2013. Stay tuned for an announcement early in the New Year, when dates and venue will be finalized. AQUA is hoping to provide support for two students to attend. We will release details on how to apply shortly, via AQUAlist and the facebook page. For more information, contact Craig Sloss (c.sloss@qut.edu.au).

And finally…

Submissions are welcomed for suggested captions for the following photo courtesy of Peter Almond…

QA

A reassessment of Last Interglacial deposits at Mary Ann Bay, Tasmania

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Abstract

Sandy deposits containing shells occur at c. 20 m above present high water mark at Mary Ann Bay in southern Tasmania, Australia. Shells in the deposits have previously been dated to the Last Interglacial by amino acid racemisation analysis and on this basis the deposits have been interpreted to be marine, indicating rapid uplift of about 0.15 m/ka in the area. The sandy deposits, interlayered with sandy loam and sandy clay layers in the lower part of the section, overlie weathered dolerite. The section was redescribed and the sands were dated by thermoluminescence methods. Ages of 30.7±1.9 ka and 30.3±3.7 ka indicate deposition of the sands during the Last Glacial, and are incompatible with a marine origin. The presence of layers interpreted to be palaeosols, lag deposits and cross bedding support aeolian transport of sands by winds from the southwest. We interpret the sands to be a remnant of an extensive aeolian deposit that accumulated east of the lower Derwent floodplain in the Last Glacial. The sands were probably once continuous with other dated Last Glacial aeolian sands at Pipe Clay Lagoon and Llanherne near Seven Mile Beach and sandy deposits now below sea level in Ralphs Bay. The age of the shells in the Mary Ann Bay sands is not disputed, but can be explained by reworking and transport of a nearby accumulation of Last Interglacial shells by strong westerly winds.

Introduction

Mary Ann Bay on the South Arm peninsula south of Hobart, Tasmania, forms the eastern shore of the lower Derwent Estuary (Figure 1). A landslide above the bay has exposed a cliff (backwall) of sands about 8 m thick (Figure 2), which have been mapped as Quaternary 'Mary Ann Bay Sandstone' overlying dolerite (Leaman, 1972).

The presence of marine shells c. 20 m above present high water mark (HWM) at Mary Ann Bay was first noted by van de Geer et al. (1979). At the site Colhoun et al. (1982) listed 49 molluscan species found here (Appendix 1), and also noted aeolian erosion at the deposit's top. Lewis and Quilty (2009) described the foraminiferal assemblage at the site. Murray-Wallace et al. (1990) and Murray-Wallace and Goede (1991, 1995) used amino acid racemisation to date subfossil shells of *Fulvia tenuicostata* and *Pecten meridionalis* (see Appendix 1 for revised nomenclature) at the site to the Last Interglacial, and on this basis and unpublished uranium-series dating (Murray-Wallace and Goede,

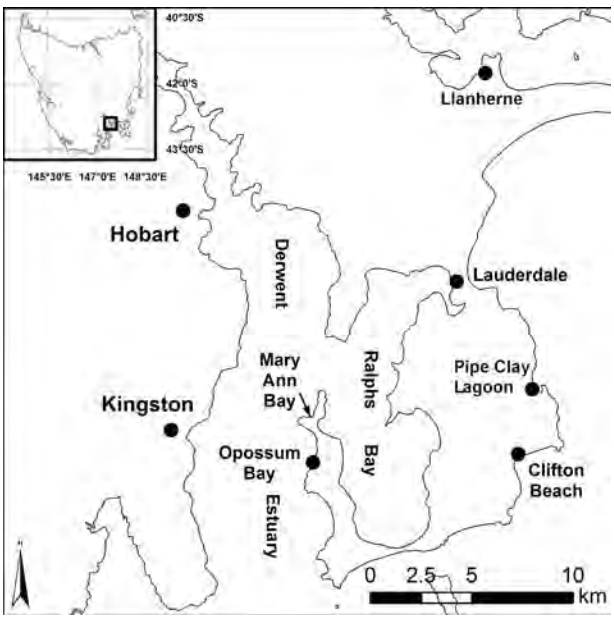

Figure 1: Location of the Mary Ann Bay site.

Figure 2: The Mary Ann Bay exposure viewed from the north, showing dolerite boulders on the beach, dolerite outcropping at right (west) and the two sites sampled for thermoluminescence dating of sands. The Derwent estuary is on the right. The bench about half way down the section marks the approximate level of the top of the in-situ weathered dolerite, largely covered by slumped sediment.

1995, p. 63) and evidence of cross stratification in the sands in which the shells were found, concluded that the deposits represented "the highest-level occurrence of last interglacial coastal sediments on the Australian continent". The elevation of the strata with respect to the highest sea level estimated globally for oxygen isotope stage 5e (c. 6 m above present HWM) was attributed to tectonic uplift: an uplift rate of about 0.15 m/ka was suggested.

The Mary Ann Bay site is enigmatic for two reasons: (1) in the region coastal benches attributed to Last Interglacial age are at 4–5 m above HWM (Davies 1959), not 20 m; although this interpretation is old, no unequivocable evidence for other Last Interglacial marine deposits or benches has since been found at this height; (2) at Pipe Clay Lagoon, also on the South Arm peninsula, but 10 km east of Mary Ann Bay (Figure 1), Last Interglacial beach sands occur at present-day sea level and are overlain by Last Glacial aeolian sands radiocarbon dated 26.3±0.8 cal ka (Colhoun, 1977; SUA153/2; calibration by CalPal (Weiniger and Joris, 2008)) and there is no evidence of tectonic activity between the two sites.

The Mary Ann Bay deposits therefore deserve closer scrutiny. The four alternative explanations for the deposits are: (1) the amino acid racemisation age is sound, the interpretation of Murray-Wallace and Goede (1991, 1995) is correct, and the sediments enclosing the shells were laid down during a Last Interglacial high sea level; (2) the amino acid racemisation age is correct but the shells have been reworked and the sediments enclosing the shells have a different age and may have been laid down by a non-marine process; (3) the amino acid racemisation age is incorrect and the sediments were laid down by a high sea level but not during the Last Interglacial; (4) the amino acid racemisation age is incorrect and the shells and their enclosing sediments have been laid down by a non-marine process.

Assuming the published analyses and their age interpretation are correct (and there are no grounds for doubting them), explanations 3 and 4 must be rejected and explanation 2 must be assessed against explanation 1 (the published interpretation). Explanation 2 requires evidence for reworking of the large shells and evidence for non-marine processes. This paper examines such evidence.

Methods

The Mary Ann Bay section was re-examined and re-described according to conventions of the National Committee on Soil and Terrain (2009) (Table 1). Slumping obscured the sedimentary sequence below 6.8 m depth and the description of the section between 6.80 m and 9.45 m is based on auger samples. Total depth to high water mark was measured using a tape measure, and adjusted for the angle of the cliff face. Samples for thermoluminescence dating were taken at the depths indicated in Table 1 and Figure 3 using light-proof tins 10 cm diameter and 12 cm deep, vertically tapped into the sands using a hammer (Figure 4). The columnar Bk (carbonate-veined) horizon of the present-day soil was avoided for thermoluminescence dating because of possible recent sand movement down soil cracks. The orientation and angle of dip of foresets at each of the TL sampling sites were measured, as were the orientation and angle of dip of coarse sand and shelly deposits. Size analysis of the sands at the five sites (including the two TL sites) was by wet sieving. TL dating was performed using the methods described by Shepherd and Price (1990) and Nanson et al. (1991).

Table 1. Stratigraphic description (composite profile).

Layer	Depth (m)	Interpretation	TL age (ka)	Sample for particle size	Brief description
3.5	0-0.80	Dunesand			Dark brown (7.5YR3/2) medium sand; loose. (A1 horizon)
3.4	0.80-1.00				Brown (10YR4/3) medium sand; weak. (AB horizon)
3.3	1.00-2.30				Yellowish brown (10YR5/4) medium sandy loam; firm; columnar structure (columns 0.20-0.60 m diameter); columns coated with calcite c. 10 mm thick, and some with organic matter coatings; shells (mostly angular, thin, weathered and fragmental) up to 60 mm diameter concentrated in bottom half of horizon, where they form layers. (Bk horizon)
3.2	2.30-7.70		W4475 2.90– 3.10 m **30.7±1.9** W4476 6.70–6.80 m **30.3±3.7**	P1: shelly band at 2.5 m P2: 2.90-3.10 m	Light yellowish brown (2.5Y6/4) medium sand; many coarse shell fragments 2 mm diameter, few fragments >2 mm concentrated in shelly band near top of layer; carbonate flecks; sediment is banded with coarse sands and fine sands; weak. (C horizon)
3.1	7.70–8.05			P3: 7.80–7.90 m	Light yellowish brown (2.5Y6/4) sandy clay loam with bands of coarse and medium sand including shelly fragments 1–2 mm; firm.
2.3	8.05–8.45	Palaeosol		P4: 8.30–8.40 m	Greyish brown (10YR5/2) sandy clay loam with carbonate veins 1 mm diameter; no shelly fragments; firm. (Buried Bk horizon)
2.2	8.45–8.80	Dunesand			Light olive brown (2.5Y5/4) sandy loam; no shelly fragments; weak.
2.1	8.80–9.40	Dunesand		P5: 9.00–9.10 m	Yellowish brown (10YR5/4) fine sand; no shelly fragments; loose.
1.3	9.40–9.45+	Palaeosol			Dark greyish brown (10YR4/2) sandy clay; abundant carbonate veins and hard concretions; very firm. (Buried Bk horizon)
1.2	c. 10.00-10.50	Strongly weathered dolerite			Greyish brown (10YR3/2) clay; water-saturated.
1.1	10.50-18.00	Weakly weathered dolerite			Rock; wave-cut bench at 0.5 m above high tide mark.

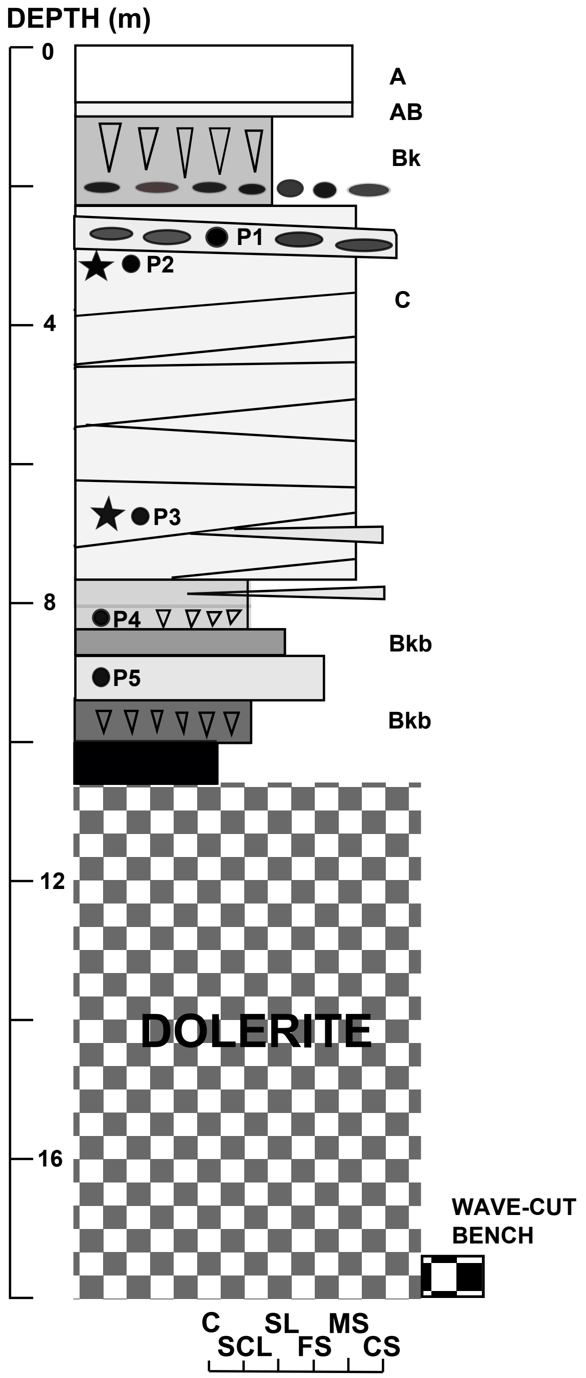

Figure 3: Stratigraphic section. P1–P5 indicate locations of samples for particle size analysis. Stars indicate positions of samples for TL dating. Ellipses indicate shell fragments. Inverted triangles indicate carbonate veins. C = clay; SCL = sandy clay loam or clay loam; SL = sandy loam; FS = fine sand; MS = medium sand; CS = coarse sand. Textures are field textures (National Committee on Soil and Terrain 2009).

Results

Field observations

The sedimentary deposits are 9.4 m deep and overlie weathered dolerite (Figures 2 and 3; Table 1). The top 7.70 m of the deposit consists of sands and sandy loams (Table 2). Below 7.70 m depth sandy clay loam, sandy clay and clay layers occur, with a distinct interlayered band of fine sand at 8.80 m. The clay layer is water saturated and occurs at the top of the in-situ weathered dolerite at about 10 m depth. It probably constitutes the slip plane over which the overlying slumped sedimentary layers have moved. Shelly fragments up to 2 mm diameter occur in all layers above 8.05 m but not below. As noted by Colhoun et al. (1982) intact shells are abundant only near the top of the section. They occur in the Bk horizon of the present-day soil and in the top of the C horizon, where they form a band dipping westwards at 11º over a distance of 3 m (the shelly band at the top of the C horizon, illustrated in Figure 3). All shells show some damage and many are perforated by the borings of marine organisms. The maximum shell diameter measured was 60 mm, and most of the larger shells are flat (left) valves of *Pecten* species. The smaller shells are gastropods mostly 6–8 mm long. No palaeosols and no stratigraphic breaks are evident within the sandy material, except that the bottom of the shelly band at 2.3 m depth has a distinct boundary with the medium sand below (Figure 2), forming a disconformity. Bedding is mostly close to horizontal to undulating, over a wavelength of about 120 mm. However cross bedding was noted, not only in the shelly band (see above) but at both TL sampling sites where foresets 100–300 mm long dipped at 17º and were oriented at 77ºE with respect to true north at the upper TL site and at 64ºE at the lower TL site.

Thermoluminescence ages

The TL ages obtained were 30.7±1.9 ka at 2.90 m depth and 30.3±3.7 ka at 6.70 m depth (Table 3). Both samples analysed exhibited excellent TL characteristics with lengthy temperature plateau comparisons and regenerated TL growth curves having r-square coefficients approaching unity, lending confidence to the resultant TL ages. Essentially the two ages obtained are the same and indicate that the sands at these depths were deposited at about 31 ka.

Mollusc assemblage

The species present in the shell assemblage (Colhoun *et al.* 1982), with species names updated in Appendix 1) support an origin in a similar climatic and geographic environment to that of the lower Derwent River estuary today (i.e. a warm interglacial period, with a mixture of rocky and sandy shores), except that some species present are now found only further north, so slightly warmer conditions than those prevailing today are implied. In addition, some species in the assemblage prefer high energy 'ocean beach' environments, so a beach bordering the southern ocean is likely to have been close by.

Figure 4: Sampling sites for dating. Left: top TL site (white arrow); note Bk horizon at the level of the hammer, with prominent calcite veins on faces of prisms; black arrow marks the boundary of the Bk and C horizons of the present-day soil. Right: the lower TL site (white arrow).

Discussion and conclusions

The stratigraphy of the section (Figure 3 and Table 1) indicates the presence of subsoil layers of two palaeosols, identified as buried Bk horizons with sandy clay/ sandy clay loam textures. The buried Bk horizons correspond to the well-developed Bk horizon of the present-day soil. The lower palaeosol is overlain by the fine sandy layer, and the upper one by a medium sand. If the fine and medium sands had accumulated by wave action (i.e. on a beach) one would have expected the palaeosols and the clay layer on top of the weathered dolerite to have been eroded, and the dolerite bench to have boulders on its surface (like the present beach (Figure 1)) but this is not the case.

The TL ages obtained are evidence for a non-marine origin for the sands because there is no evidence for high sea level at 31 ka. The dominance of fine sands in samples P1–P3 and P4 is compatible with an aeolian origin and sands could have blown to the site by west-southwesterly winds from the now drowned Derwent River

Table 2. Particle size analysis, by weight.

Sample no.	Particle size, <2 mm fraction (mm)				Field texture
	2.0–0.6 Coarse sand	0.6–0.2 Medium sand	0.2–0.06 Fine sand	<0.06 Silt and/or clay	
P1	19	34	35	12	Coarse sand*
P2	0	26	57	17	Medium sand
P3	0	25	58	17	Medium sand
P4	0	2	46	52	Sandy clay loam
P5	0	10	77	13	Fine sand

* This is the shelly band illustrated in Figure 3.

valley. The lag deposit of shells on the low-angle western-aspect bedding plane and the shorter but steeper angle foresets (without shells) on the eastern-aspect foresets supports an interpretation of accumulation under the influence of westerly winds. The relatively high proportion of clay in some layers (e.g. sample P4 from 8.05–8.45 m depth) is readily explainable by the persistence of the clay layer on top of the dolerite during sand deposition: some mixing of clay aggregates with sands by physical or biological processes can be assumed. The absence of significant weathering (other than carbonate dissolution and redistribution) in the sands, and specifically their generally low clay content and lack of cementation (Mary Ann Bay 'Sandstone' is a misnomer) also argues against a Last Interglacial age.

Except for its top 3 m, the deposit is unremarkable and similar to extensive aeolian deposits in the lower Derwent estuary, some of which have been dated to the Last Glacial (Donaldson 2010). Problems of interpretation centre on the shells in the top 3 m of the deposit, and to a lesser extent, with the shelly fragments which occur to 8.05 m depth. None of the shells are in place, many are fragmental and all whole shells are disarticulated. It appears that the shells and the shelly fragments have been eroded from a Last Interglacial beach deposit that is no longer extant, and transported to the site by very strong winds.

Table 3: Analytical details for TL age determinations.

	Upper TL site	Lower TL site
Depth (m)	2.90	6.70
Plateau region (°C)	300–500	300–500
Analysis temperature (°C)	375	375
Palaeodose (Grays)	41.2±2.3	39.6±4.8
K content by AES (%)	0.590±0.005	0.585±0.005
Rb content (ppm assumed)	50±25	50±25
Moisture content (% by weight)	3.4±3	8.4±3
Specific Activity (Bq/kg U+Th)	29.8±0.9	34.0±0.9
Cosmic contribution (μGy/yr assumed)	141±25	99±25
Annual radiation dose (μGy/yr)	1344±28	1307±28
TL age (ka)	30.7±1.9	30.3±1.9

The change of particle size from the bottom to the top of the section, i.e., from the fine sand layer at 8.80 m depth (77% fine sand), to the medium sand layer at 2.3–7.70 m (57–58% fine sand) to the shelly band (35% fine sand) (Table 2) is interpreted to indicate deposition under progressively increasing wind speeds. It is possible that the wind speeds required to move shells, presumably by a process of repeatedly 'flipping' them over, could be calculated by wind tunnel experiments.

We interpret the Mary Ann Bay sands to be a remnant of once extensive aeolian deposits that formed downwind (east) of the lower Derwent River floodplain in the Last Glacial period; these deposits include the aeolian sands dated 26.3±0.8 cal ka at Pipe Clay Lagoon (Colhoun 1977) and those 15 km northeast of Mary Ann Bay at Llanherne near Seven Mile Beach, dated 26.1±3.4 ka and 53.7±3.5 ka by thermoluminescence methods (Donaldson 2010). In the Last Glacial these dated deposits, associated sand dunes and sand sheets, and sands now forming the shallow sea floor in Ralphs Bay would have formed a continuous aeolian cover. It is noteworthy that the 31 ka age of the sands coincides with the peak of erosion and deposition in Tasmania (McIntosh *et al.* 2009, Figure 8; McIntosh 2010) which raises the likelihood that the Derwent River carried large sediment loads into the area of the present estuary at around 30 ka, and that these alluvial sediments were the source of the aeolian sands.

Acknowledgements

Size analysis was by Ralph Bottrill, Mineral Resources Tasmania.

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Appendix 1. Species list of shells in the upper part of the section at Mary Ann Bay (based on Colhoun et al. 1982, with species names updated). The list is in approximate taxonomic order. R = Rock; S = Sediment; E = Estuarine.

Species	Habitat	Comments
Gastropods		
Patellidae		
Scutellastra chapmani (Tenison Woods, 1876)	R	An uncommon species on rocks in local assemblages today, but commoner further north; the more southern species *Scutellastra peronii* (Blainville, 1825) predominates today
Eoacmaeidae		
Eoacmaea calamus (Crosse and Fischer, 1864)	R	Shallow subtidal on rocks
Lottiidae		
Notoacmea flammea (Quoy and Gaimard, 1834)	R	Intertidal and shallow subtidal on rocks, mostly on sheltered shores
Trochidae		
Bankivia fasciata (Menke, 1830)	S	Very shallow subtidal, mostly on 'surf' beaches
Hydrococcidae		
Hydrococcus brazieri (Tenison Woods, 1876)	S; E	Lives on algal mats and biofilms in sheltered lagoons and estuaries
Turritellidae		
Colpospira australis (Lamarck, 1822)	S	Shallow subtidal, in sand
Cerithiidae		
Cacozeliana granaria (Kierner, 1842)	S; R	Shallow subtidal, on sand and in crevices among rocks
Dialidae		
Diala suturalis (A. Adams, 1853)	S; E	Intertidal and shallow subtidal; on algal mats and biofilms in sheltered lagoons and estuaries
Calyptraeidae		
Calyptraea calyptraeformis (Lamarck, 1822)	S	Lives attached to other mollusc shells, mostly on sandy substrates
Maoricrypta immersa (Angas, 1965)	S	Lives attached to other mollusc shells, mostly on sandy substrates
Sigapatella hedleyi (Smith, 1915)	S	Lives attached to scallops and other bivalves, mostly on sandy substrates
Naticidae		
Notocochlis sp.	S	Species most likely to be *Notocochlis subcostata* (Tenison Woods, 1878); ploughs through sediment seeking molluscan prey
Polinices conicus (Lamarck, 1822)	S; E	Ploughs through sediment seeking molluscan prey; common in estuarine settings
Cerithiopsidae		
Seila albosutura (Tenison Woods, 1876)	?	Shallow subtidal; lives among sponges (on sandy or rocky substrates)
Fasciolariidae		
Fusinus novaehollandiae (Reeve, 1848)	S	Shallow subtidal to offshore on mud; predator
Pleuroploca australasia (Perry, 1811)	S; R; E	Intertidal and shallow subtidal predator; also found in sheltered saltwater lagoons

Buccinidae		
Cominella lineolata (Lamarck, 1809)	S; R; E	Intertidal; predatory/scavenger; occurs on rocks as well as soft substrates, including estuaries
Columbellidae		
Mitrella spp.	S: R; E	Small intertidal and subtidal predators; some species prefer estuarine settings, others rocky shores.
Nassariidae		
Nassarius nigellus (Reeve, 1854)	S	Shallow subtidal predator, not particularly estuarine.
Nassarius pauperatus (Lamarck, 1822)	S; E	Intertidal and shallow subtidal predator; prefers estuarine settings
Muricidae		
Bedeva paivae (Crosse, 1864)	S; R; E	Lives on mussel-beds etc., preying on bivalves, especially in estuarine settings
Litozamia petterdi (Crosse, 1870)	R	Shallow subtidal among rocks; predatory
Conidae		
Guraleus alucinans (Sowerby, 1896)	S; R	Shallow subtidal to offshore, probably mostly under stones or rocks
Guraleus incrustus (Tenison Woods, 1876)	S; R	Shallow subtidal to offshore, probably mostly under stones or rocks
Orbitestellidae		
Microdiscula charopa (Tate, 1899)	?	Probably lives among macroalgae; a tiny micromollusc
Pyramidellidae		
Syrnola tincta (Angas, 1871)	?	Shallow subtidal; probably parasitic on other benthic animals (could be on sandy or rocky substrates)
Bivalves		
Nuculidae		
Leionucula obliqua (Lamarck, 1819)	S	Shallow subtidal to offshore, probably in fine sand
Glycymerididae		
Glycymeris sp.	S	Species is most likely to be *G. striatularis* (Lamarck, 1819); shallow subtidal in sand, mostly on 'ocean' beaches
Mytilidae		
Mytilus galloprovincialis planulatus (Lamarck, 1819)	S; R; E	Taxonomy uncertain; currently favoured theory is that there is an endemic subspecies that favours exposed rocky shores, and that estuary-dwelling and sheltered-shore mussels are a recent (post-European) introduction, and that the two subspecies have probably now introgressed
Pectinidae		
Chlamys aktinos (Petterd, 1886)		Found today only on the north coast of Tasmania (and points north); shallow subtidal, amongst sponges and macroalgae
Equichlamys bifrons (Lamarck, 1819)	S	Shallow subtidal; forms beds on fine sand and mud
Mimachlamys asperrimus (Lamarck, 1819)	S; R	Shallow subtidal, amongst sponges (either on soft or hard sediments)
Pecten fumatus (Tate, 1852)	S	Shallow subtidal to offshore; forms beds on coarse and fine sand
Ostreidae		
Ostrea angasi (Sowerby, 1871)	S; E	Intertidal to shallow subtidal; forms beds and reefs on sheltered sand and mud, including in estuaries
Cardiidae		
Fulvia tenuicostata (Lamarck, 1819)	S; E	Intertidal to shallow subtidal, in fine sand in sheltered settings
Carditidae		
Venericardia bimaculata (Deshayes, 1852)	S	Shallow subtidal to offshore, in sand
Lucinidae		
Divalucina cumingi (A. Adams and Angas, 1863)	S	Shallow subtidal, in sand and mud in sheltered settings
Galeommatidae		
Lasaea australis (Lamarck, 1818)	R	Small bivalve that lives among the byssal threads of mussels etc, mostly on rocks
Mactridae		
Mactra jacksonensis (Smith, 1885)	S	Shallow subtidal, in coarse sand on 'ocean' beaches; an uncommon species in local assemblages today; more common on the upper east coast
Notospisula trigonella (Lamarck, 1818)	S; E	Intertidal to shallow subtidal, in mud, including estuaries
Psammobiidae		
Gari livida (Lamarck ,1818)	S	Shallow subtidal, in fine sand, especially in sheltered settings
Tellinidae		
Tellinella albinella (Lamarck, 1818)	S	Shallow subtidal, in fine sand, especially in sheltered settings.
Macomona deltoidalis (Lamarck, 1818)	S; E	Intertidal to shallow subtidal, in mud, including estuaries
Veneridae		
Notocallista kingi (Gray, 1827)	S	Shallow subtidal in sand; an uncommon species in local assemblages today; its southern congener *N. diemensis* (Hanley, 1844) is more common
Timoclea cardioides (Lamarck, 1818)	S	Shallow subtidal in sand
Katelysia sp.	S; E	Two common species – *K. scalarina* (Lamarck, 1818) and *K. rhytiphora* (Lamy 1935); both live intertidally in fine sand and mud, particularly in estuaries
Placamen placida (Philippi, 1844)	S	Shallow subtidal in sand
Tawera gallinula (Lamarck, 1818)	S	Shallow subtidal in sand
Paphies erycinaea (Lamarck, 1818)	S; E	Intertidal to shallow subtidal, in fine sand in sheltered settings, including estuaries

QA

The birth of the Australasian Quaternary Association

Eric A. Colhoun
AQUA President, 1985-1989, Emeritus Professor of Geography, University of Newcastle, N.S.W.

All organisms (organisations) have an exhilarating moment of conception, a longer period of gestation and an exciting moment of birth. AQUA passed through these stages which I shall endeavour to relate.

Following a Plenary Address by Dr Russell Coope at the 10th INQUA Congress in Birmingham in August, 1977, during which he enthralled the audience with a magnificent oration of why the Giant Irish Deer (Elk) became extinct, four Australians retired to the bar. After some liquid stimulus, they began to discuss the need for an Australasian Quaternary Association. To the best of my memory those participating in said liquid stimulus were Jim Bowler, David Hopley, Guus van de Geer, and myself.

The discussion sought to identify what such an association might be like and thoughts turned to the nature of the British Quaternary Research Association (QRA), which was established in 1963 following the model of the American Friends of the Pleistocene. The British QRA consisted of a group of interested Quaternary scientists that held a short field meeting each year around Easter, in a selected area where they could review, in the field, the important past work and ongoing modern studies in the region. It was particularly successful in encouraging young scientists and research students to engage with their more eminent peers and learn first-hand from senior colleagues. This seemed to be a good starting point for the conception of AQUA.

In 1977, following the Birmingham INQUA, Jim Bowler extended the proposal for a group like AQUA through the pages of the 10th Australian Quaternary Newsletter (AQN). He endeavoured to assess the degree of interest in forming "An Australasian Quaternary Association: To be or not to be?". In the succeeding 11th AQN he reported that he had 36 replies. These represented 15% of the individuals receiving the AQN, 32 of whom would favour meetings to address Quaternary problems, and 28 of whom preferred a combined meeting of Australian and New Zealand participants and field trip every two years. As a result of the small number of replies Jim considered "it is (was) probably premature to make any immediate plans to set up a Quaternary organisation". However the gestation was proceeding. It was greatly enhanced by the occurrence of three significant meetings in the years following.

In response to the suggestion that a field excursion should be run in Australia, I offered to organise a Quaternary Excursion to northwest and west Tasmania. This was held in April 1979. The highlights of the excursion included flying to Hunter Island to examine the archaeological site of Cave Bay Cave which was demonstrated by Sandra Bowdler; descending into the animal trap of Pleistocene Cave with Albert Goede and Peter Murray; getting bogged in the wet sediments of Pulbeena Swamp with myself and Guus van de Geer; and ascending the 300 m-high Hamilton Moraine on a 10-20 degree inclination (see photo). The party of 23 had been joined by Geoffrey Hope and a minibus of ANU students - the life-blood of the future. Apart from those mentioned, the main party contained numerous prominent individuals including Nel Caine, Bob Galloway, Patrick de Deckker and others, and Rhys Jones and Gurdip Singh who alas have now left us. The benefits of this intellectual interaction were wonderfully displayed in the evening at Smithton Hotel by an exhibition of contrasting views on how the Australian Aboriginal people got to Tasmania (was it round the coast or through the centre of Australia?). Such an exhibition could only be so vehemently expounded through debate between a flamboyant Welshman and an insightful Australian. Following the Tasmanian excursion the intention was to have another soon afterwards on the mainland.

The second major event of significance that catalysed Quaternary thought in Australasia was the First CLIMANZ meeting held at Howman's Gap, Falls Creek in Victoria in 1981. This was a most successful meeting with about 70 participants from throughout Australia and New Zealand. Its outcome was to establish the Climatic Mapping of Australia and New Zealand Project. This programme continued with regular meetings; after the 5th meeting was held in Canberrra in February 1996, a series of palaeoclimatic maps extending from Isotope Stage 7 to the Holocene in 1999 was published (see Quaternary Australasia 17/2 1999).

The third major meeting was held in May 1982 when many New Zealand Quaternarists crossed the Tasman Sea to participate with their Australian colleagues in an ANZAAS Symposium on Prehistory and Environment in the Pacific Region at Macquarie University. The success of this meeting finally confirmed the need for a combined organisation of Australian and New Zealand Quaternary scientists. The birth of AQUA was nigh.

At a special evening meeting arranged during the Symposium, Jim Bowler proposed from the Chair that we should consider establishing an Australasian Quaternary Association. After considerable discussion, AQUA was born. This was a great step forward for Quaternary science in the southwest Pacific region. Following the formal establishment of AQUA, the name of the Australian Quaternary Newsletter, which had first been published in March 1973 and was nurtured for many years by Jeanette Hope and Bruce Thom, was changed to Quaternary Australasia. This was proudly announced by Martin Williams with the publication of numbers 1 and 2 of Volume 2 (Vol. 1 being the preceding AQN) in May 1984, under his editorship.

The first major event of AQUA was a Field Meeting to Mildura in 1986. The highlight was a visit to Lake Mungo and the "Walls of China", led by Jim Bowler and soon to be repeated as part of the 30th Anniversary celebrations of the founding of AQUA, in 2014. If it is anything like the first meeting, it will be something that Australasian Quaternarists will not want to miss.

Since the birth of AQUA in 1982 it has handsomely fulfilled many of its expectations and contributed to significant expansion in Australasian Quaternary studies. The interaction between senior and younger scholars and graduate students has been most fruitful. Field excursions have been held biennially; without naming all locations, parties have visited the fascinating regions of Lake Eyre, Fraser Island, Westport (New Zealand) and Cradle Mountain (Tasmania). AQUA has also played a key role in organising several international conferences held in Australia. The continued publication of an expanded Quaternary Australasia has not only acted as a Quaternary information medium within Australasia, but is also a vehicle that takes the work of Australasian Quaternarists, particularly young Australasian researchers, to the world. I convey to all members of AQUA - including those now responsible for its progress and development - every good wish at the time of its 30th Anniversary, and into the future.

QA

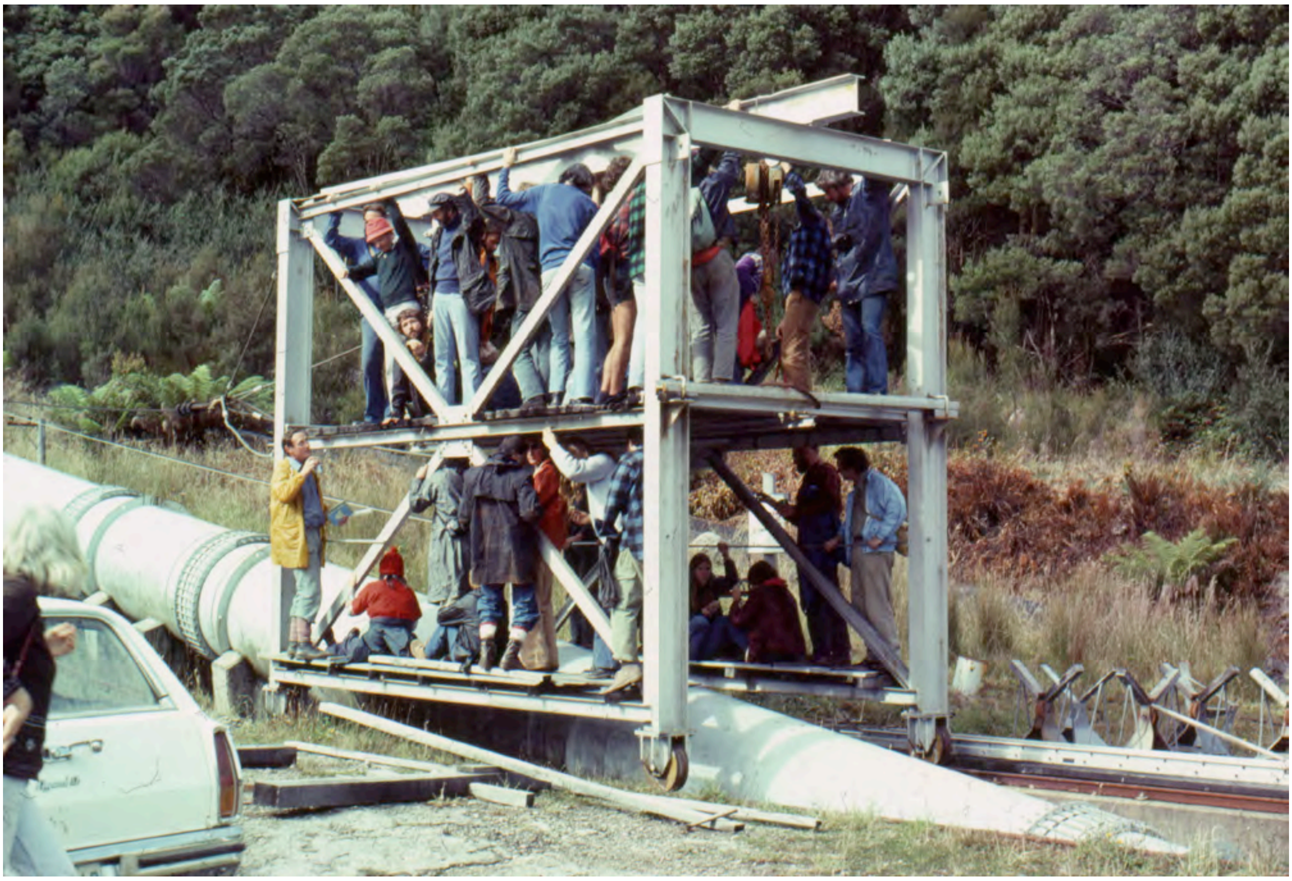

Photo caption: Future members of AQUA ascend the 300 m high Hamilton moraine to Lake Margaret in an inclinator, Quaternary Excursion to northwest and west Tasmania, April 1979. Photo credit: Eric Colhoun (digitised by Bill Landenberger).

Icons of the Australasian Quaternary

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This year the Australasian Quaternary Association reaches the venerable age of 30. Given the long and esteemed history of Quaternary science in our region, this is a good time to take stock of the important field sites which have fundamentally influenced our thinking within the discipline. Here are proposed a number of "iconic" sites which have made significant contributions to our understanding of the past, based on suggestions from the community at large.

The definition of what constitutes iconic is open to debate. Does this refer to sites which have made important contributions to the discipline in general; have global significance and place the region in context; are controversial archives which have generated debate; provide overarching palaeoenvironmental frameworks over long timescales; or provide high resolution detail about critical time periods and thresholds? Each of these criteria is equally valid. I have tried to propose sites which have played an important role in helping us understand the major landmarks, both geographically and within the history of our science.

The list proposed here represents a synthesis from members of the community. Although initially my plan was to narrow the list down to ten, it soon became clear that a larger number of sites than expected ticked the boxes. It is a testament to the diversity and interdisciplinarity of our field that the number hovers around 20! In many cases the sites revisit AQUA's early roots, and many remain hotspots of scientific research today. Many of the sites hold World Heritage status. By and large the sites are terrestrial, and I have tried to organize them into broadly geographic themes. Some sites, naturally, transcend these categories. There is a notable geographic bias towards southeastern Australia, which more than likely highlights the historical intensity of research in this region. In any case, the list reflects the state of the art, and emphasizes emerging themes as well as gaps in our understanding of the Australasian Quaternary. I certainly learnt a lot during this exercise, and I hope that the list provokes further healthy debate amongst the community!

The distant past: long records of environmental change

In Australia, a continent often characterized by relatively low sediment availability and fragmentary geomorphic records, the Holy Grail has ever been the discovery of long, continuous palaeoenvironmental sequences. The Quaternary renaissance of the 1960s and 1970s stimulated significant work on several such archives. These studies substantially extended the known record into the distant past, and remain significant hotspots of research today.

Lynch's Crater, perched atop the Atherton Tablelands inland from Cairns in tropical northeast Australia, is one of the best examples of these long records. The volcanic crater itself formed ca. 250 ka, and contains a largely continuous sequence of lacustrine and swamp sediments which initially formed the focus of palynological studies elucidating change over long timescales (Kershaw 1974). This work was followed by investigations of charcoal content which suggested evidence of Aboriginal burning in the landscape (Kershaw 1986). Subsequent interdisciplinary studies, incorporating new proxies and revision of age models, fortified the original palaeoclimatic interpretations (Turney *et al.* 2006), and lately used the palaeoecological record to weigh into the megafaunal extinction debate (Rule *et al.* 2012). The Lynch's Crater sequence also suggests periodic abrupt southward propagation of the intertropical convergence zone coincident with northern hemisphere Heinrich events, thereby providing evidence of interhemispheric teleconnection (Muller *et al.* 2008).

Lake George, straddling the Great Divide, provides one of the most complete records of Quaternary sedimentation in temperate southeastern Australia. It was here that Galloway first considered the possibility that lower temperatures could cause reduced evaporation and lake filling during the last glacial maximum (LGM) (Galloway 1965). The site – one of the nation's largest freshwater lakes when full – initially attracted the attention of Quaternarists by virtue of its long sequence of lacustrine sedimentation and preservation of multiple shorelines (Coventry 1976; Singh *et al.* 1981). Unfortunately, the accuracy of radiocarbon dating within the cores – and therefore correlation with the timing of climatic cycles - was called into question due to evidence for systematic contamination (Singh *et al.* 1981; Singh and Geissler 1985). Recent optically stimulated luminescence (OSL) dating of the lake shorelines has begun to address this problem (Fitzsimmons and Barrows 2010), and much work is in progress on one of the continent's longest terrestrial records.

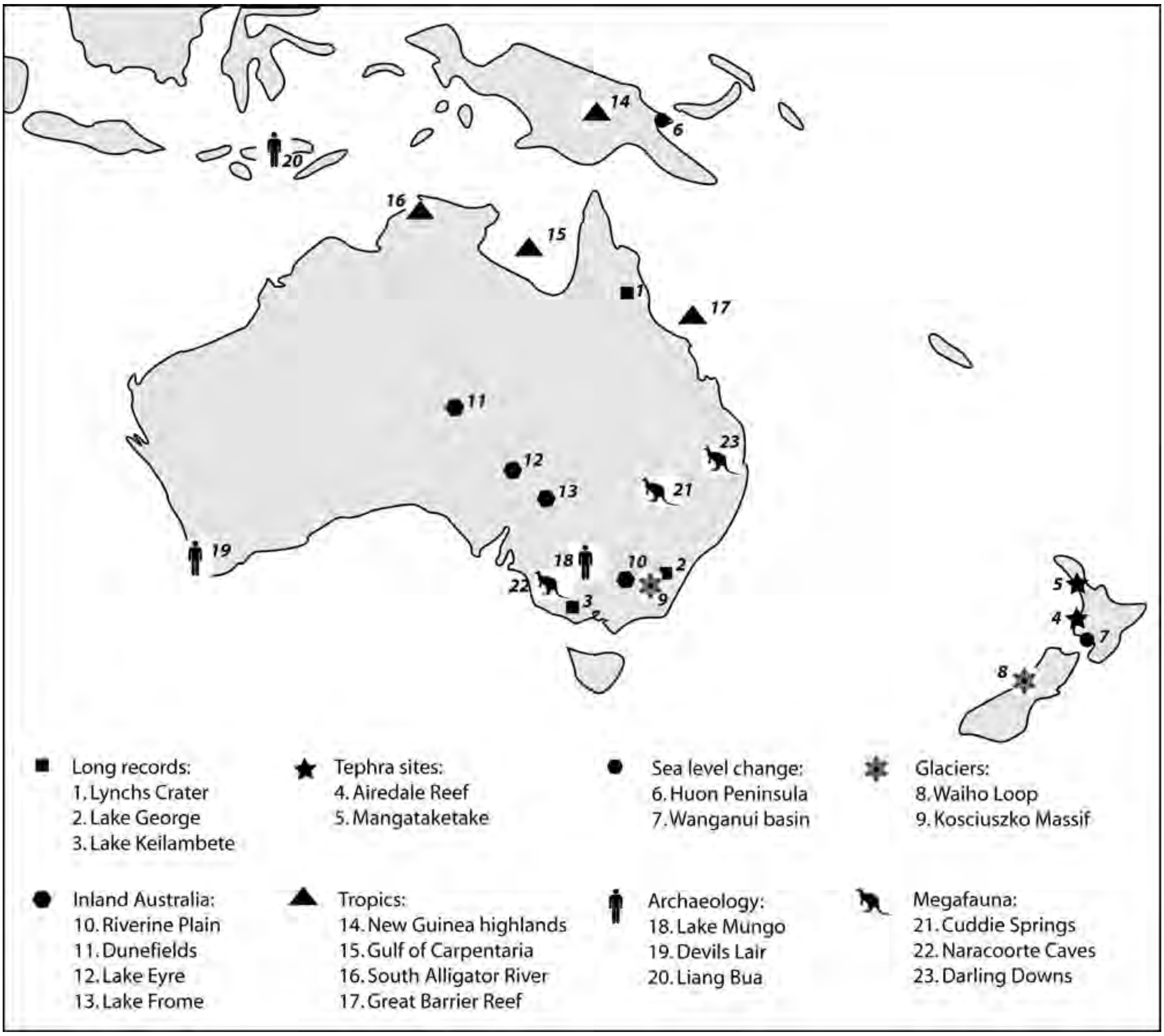

Figure 1: Map of Australasia, showing the locations of the "iconic" sites proposed in this essay.

Lake Keilambete in southwestern Victoria, a crater lake representing an effective rain gauge for the region, presented an early breakthrough in Quaternary palaeoclimate reconstruction in the Australian temperate zone, by extending the reliably dated archive beyond the LGM (Bowler and Hamada 1971). The Lake Keilambete sediments provided one of the earliest direct radiocarbon chronologies in Australia. The Keilambete record was later augmented by pioneering palaeosalinity studies derived from ostracod biomarkers (Chivas *et al.* 1985), and by comparisons between conditions prior and subsequent to European arrival (Mooney 1997). High resolution investigations of the lake sediments, involving the application of multiple proxies and geochronological techniques, are ongoing (Wilkins *et al.* 2012).

Marking time

Direct temporal correlation between different sites, and therefore syntheses of palaeoclimatic events, has ever been fraught with difficulty, given the oft ambiguous nature of proxies and reliance on geochronological techniques with variable precision. New Zealand's active volcanism, however, has generated a large number of tephra, which as isochronous marker beds have enabled regional and interregional correlation of equivalent-aged sequences. Nowhere can the role of tephrochronology in the New Zealand context be better demonstrated than by the sequence preserved at ***Airedale Reef*** in Taranaki, western North Island (Newnham and Alloway 2004). Here, the Airedale Reef section overlies a wave-cut terrace correlated to MIS 5e and comprises a thick cover-bed sequence of alternating reddish and yellowish andic soil materials interbedded by andesitic tephras sourced from Egmont Volcano. Included within the sequence are two widespread rhyolitic tephras erupted from the central North Island - the mid-MIS 2 Kawakawa/Oruanui Tephra and the early MIS 3 Rotoehu Tephra. The lower part of the sequence comprises organic-rich sediments enveloping a thick debris avalanche deposit, and provides a continuous palaeoecological record which corresponds with marine isotope stratigraphy. This includes a five-stage subdivision of MIS 5, which supports the contention that orbital variations were a primary factor in palaeoclimatic change in the southern hemisphere mid-latitudes over this time period. The occurrence of widespread tephra markers interbedded within Quaternary sediments have certainly facilitated correlation with more fragmentary equivalent-aged archives from elsewhere in New Zealand and offshore (Alloway *et al.* 2007).

Also worthy of note is the ***Mangataketake*** section at Manukau Harbour near Auckland Airport on the North Island – convenient if one is paying a flying visit! This sequence comprises spectacularly preserved fossil forest in growth position – containing pollen and beetle proxy data – which is overlain by phreatomagmatic deposits sourced from the nearby Mangataketake crater. At the onset of the eruption, mature podocarp trees were snapped in half with leaves, branches and small trees entrained and preserved within the ash deposits (Marra *et al.* 2006). The sequence was correlated with MIS 7 and extended the known age of volcanism in the region by up to 40 ky.

Sea-level change

Global palaeoclimate during the Quaternary was influenced both by variations in solar insolation, and marine and atmospheric transfer of heat from the low to high latitudes. The rapidly uplifted coral reef terraces of the ***Huon Peninsula***, on the northeast coast of Papua New Guinea, provide one of the world's best preserved high resolution sequences of sea-level change and its relationship to variations in solar radiation (Chappell 1974). Subsequent comparison of the Huon terraces with a marine oxygen isotope curve established the significant role of deep water temperature within the global climate system (Chappell and Shackleton 1986). Palaeoclimatic correlations were later refined by revised dating (Chappell *et al.* 1996) and reinterpretation of the chronology (Edinger *et al.* 2006). Higher resolution analysis identified the preservation, within the sequence, of the response of sea level to northern hemisphere-generated Bond cycles (Chappell 2002), firmly establishing this site as one of the key Quaternary records for which sea-level change and uplift can be decoupled (Lambeck and Chappell 2001).

By comparison, the uplifted marine sequence of the ***Wanganui Basin***, along the Taranaki coast of New Zealand's North Island, provides an even longer record of sea-level change extending throughout the Quaternary to ca. 3.6 Ma (Naish *et al.* 1998). Although the significance of the sequence was recognized as early as the 1950s (Fleming 1953), investigations at this site lost some momentum until several decades later (Pillans 1983; 1994). The archive is largely

Figure 2: Airedale Reef, North Island, New Zealand. Photo: Brent Alloway.

Figure 3: Huon Peninsula uplifted coral reef terraces, Papua New Guinea. Photo: ARC Centre of Excellence for Coral Reef Studies.

represented by unconformity-bound sedimentary packages based on continental shelf deposits, known as cyclothems (Saul *et al.* 1999), with more recent isotope stages represented by uplifted marine terraces (Naish *et al.* 1998). Glacial loess is also preserved within the sequence for the most recent 12 oxygen isotope stages (Pillans 1994), and volcanic tephra is interbedded with the deposits (Alloway *et al.* 1993). The Wanganui sequence represents one of the most complete long term shallow marine records preserved on the planet, and correlates with the astronomically-calibrated Plio-Pleistocene timescale.

Ice Ages

In comparison with the larger land masses of the northern hemisphere, the bulk of Australasia has remained relatively free of ice. Nevertheless, those areas which were glaciated represent sensitive terrestrial recorders of peak cold phases, providing the potential for correlation with global palaeoclimatic events. However, as recent work attests, the relationship between glacial advance and climate is not always so straightforward.

Few southern hemisphere glacial records have been the focus of as much controversy and debate as the ***Waiho Loop moraine*** on the west coast of New Zealand's South Island. The terminal moraine forms a spectacular loop rising ca. 100 m above the foreland plain of the Franz Josef glacier. It initially received attention for providing the first evidence of the Younger Dryas climate reversal in the southern hemisphere, based on radiocarbon dating of wood from a glacially sculpted outcrop behind the moraine (Denton and Hendy 1994). The chronology was disputed through direct dating of the moraine using cosmogenic nuclides, which suggested an absence of Younger Dryas cooling in the southern hemisphere mid-latitudes (Barrows *et al.* 2007); dating of the moraines by Denton and colleagues is ongoing. Subsequent characterization of moraine sedimentology interpreted the Waiho Loop advance to have formed in response to a massive rock avalanche, rather than by climate (Santamaria Tovar *et al.* 2008). The divergence of moraine advance from climatic forcing ensures that the Waiho Loop remains the Australasian site which best highlights the uncertainties associated with the palaeoclimatic interpretation of glacial landforms (Kirkbride and Winkler 2012).

The ***Kosciuszko Massif***, Australia's highest altitude region, provides the only unambiguous evidence for Quaternary glaciation on the mainland. The massif has formed the focus of extensive scientific study since Edgeworth David proposed a three-stage model of glacial development (David *et al.* 1901). This work was subsequently challenged by Galloway (1963),

Figure 4: Waiho Loop moraine as seen from the air, South Island, New Zealand. Photo: Jamie Shulmeister.

who re-examined the likely causes of formation of individual geomorphic features. The increased availability of radiocarbon dating in the 1970s finally made chronological control possible (Costin 1972). Direct dating, by application of recently developed cosmogenic exposure methods, of the Kosciuszko Massif moraines (Barrows *et al.* 2001), finally yielded a framework for Australian continental glaciations which could be correlated with global palaeoclimate.

Of droughts and flooding rains

Large catchments are a feature of inland Australia, but few are as significant to the nation's economy as the Murray-Darling basin (MDB). The catchment is Australia's most productive agricultural region, but it is also the most exploited; its ecosystems have experienced widespread degradation since European settlement (Gell *et al.* 2009). Drought and flooding have ever characterized life in this region, although how frequent and extreme these events have been in the past is poorly understood. Many eminent Quaternarists have cut their teeth here trying to unravel past hydrologic change. The history of environmental change within the catchment is best preserved on a regional scale within its labyrinthine river channels, billabongs and palaeochannels.

Most Quaternary studies within the MDB focused on channel variability on the ***Riverine Plain*** in southern New South Wales. Source-bordering dunes and fluvial terraces on the Riverine Plain have been of interest to researchers since Sturt's explorations in the 19th century (1833), but did not receive systematic scientific attention until the soil and geomorphic studies from the 1950s onward (Page 1971; Beattie 1972). The pioneering work of Butler (1958; 1967) highlighted the utility of paleosols within the ancient floodplain deposits for palaeoenvironmental reconstruction. He also provided the first description of far-travelled dust accumulation in the region (Butler 1956), prompting several academic generations of debate regarding the distinction – or otherwise – of so-called "parna" from loess (e.g. Haberlah 2007). The advent of luminescence dating was responsible for establishing a chronostratigraphic framework for the response of MDB channels to Quaternary palaeoclimates (Page *et al.* 1991; 1996; 2001). More recent work has attempted to systematically untangle the potentially ambiguous responses of fluvial systems to climatic influences (Kemp and Rhodes 2010). Chronologies of MDB fluvial geomorphology provide an invaluable framework for hydrologic phases relating to palaeoclimatic conditions during the last full glacial cycle.

Figure 5: Blue Lake cirque, Kosciuszko Massif, southeastern Australia. Photo: Tim Barrows.

Into the arid heart

As Dorothea McKellar famously lyricized, Australia is a sunburnt country. Approximately half of its landmass is presently arid or semi-arid, and one third of the mainland is covered by linear desert dunes. The ***Australian desert dunefields*** constitute one of the continent's more iconic landforms, having long been a source of fascination to Quaternarists. Early explorers saw little scientific or agricultural interest in the arid heart (Sturt 1849; Gregory 1906), until the first systematic attempt at mapping the Simpson Desert by Madigan (1936). This was followed by mapping at the continental scale (Jennings 1968), which highlighted the inescapable fact that desert dunes are preserved beyond the presently arid zone. The orientation and distribution of the dunes prompted hypotheses that the areal extent of the arid zone must have fluctuated in response to the global climate cycles (Bowler 1976; Mabbutt 1986) and past wind regimes (Sprigg 1982). However, arguments for dune formation during cold, dry glacial periods could not easily be verified due to lack of preservation of organic material, which prevented dating using radiocarbon. The development of luminescence dating techniques, ideally suited to the sunny aeolian environments of the Australian arid zone, provided the first direct dating of sediments in the region (Readhead 1988). It would take almost two more decades, however, before OSL dating was applied to desert dunes on a large scale to provide the first chronologic framework for the timing of central Australian dune activity (Fitzsimmons *et al.* 2007). Significantly, in the few years since then, the relationship between dunes and palaeoclimate has been shown to be more complex than previously anticipated (Hesse 2010; Lomax *et al.* 2011).

The shorelines of the major terminal playas ***Lakes Eyre and Frome***, also in the central Australian arid zone, contribute valuable information relating to Quaternary palaeohydrology, although these large catchments respond more closely to distal, rather than local, palaeoclimatic influences. Lake Eyre provides valuable semi-continuous records of palaeo-monsoon activity over the last full glacial cycle (Magee *et al.* 2004). By contrast, it has been proposed that Lake Frome responds variably to runoff within the westerly- and monsoon-dominated portions of this catchment (Cohen *et al.* 2011; in press).

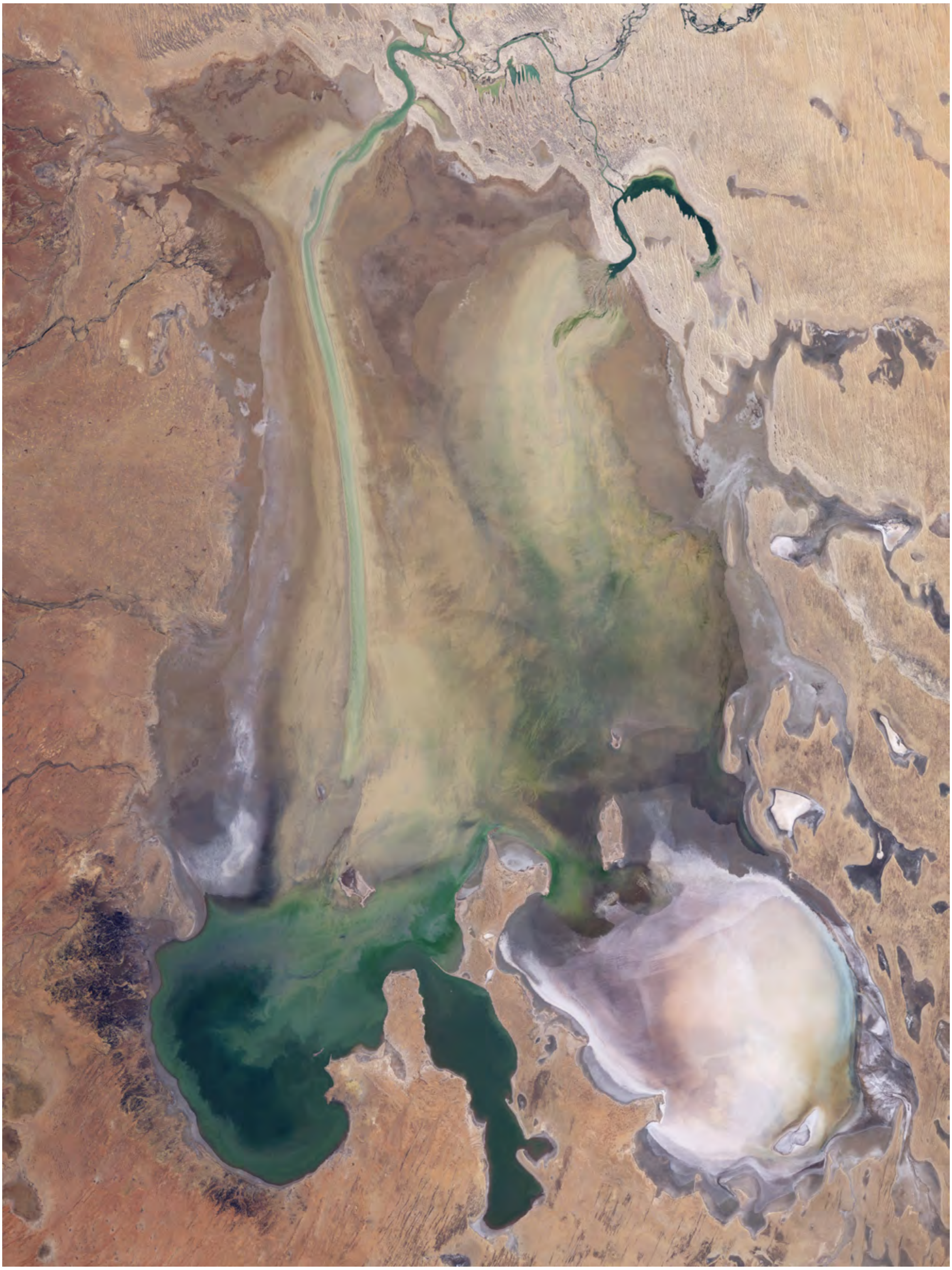

Figure 6: Lake Eyre, central Australia. Photo: NASA.

Discovering the tropics

Remote, comparatively unexplored, full of dangerous animals: the Australasian tropics eluded Quaternarists until relatively late in the history of our science. The tropics, however, play an important role in the global redistribution of heat, and the studies of intrepid Quaternarists from the 1970s onward demonstrated that there was much to be gained from working in hot, sticky places. The tropics have since yielded a number of iconic sites which hold significance for understanding palaeoclimates on a hemispheric scale.

The ***highlands of New Guinea***, strategically placed adjacent the Indo-Pacific warm pool, preserve evidence of a number of glaciated areas from the Pleistocene (Loeffler 1972). Glaciation in the highlands therefore provides a clue to changes in temperature of one of the planet's largest heat engines. The first palynological studies in this region – at Mt Wilhelm (Hope 1976) and Enga Province (Walker and Flenley 1979) in Papua New Guinea – investigated changes in tree-line altitudes from the LGM, and inferred a substantial reduction in temperature which contradicted global models for temperature change (CLIMAP 1976). However, the lack of direct dating of glaciation and the potential for incorrect attribution of these events remained a significant limitation. Recent direct dating of glacial moraines at Mt Giluwe – another breakthrough thanks to the development of cosmogenic exposure dating techniques – provided the first framework for multiple glaciations in tropical Australasia (Barrows *et al.* 2011). This has prompted reassessment of earlier palaeoclimatic interpretations and reestablished the highlands as a significant Quaternary archive.

The periodic exposure of substantial areas of continental shelf within the Indo-Pacific warm pool holds significant implications for the transport of latent heat from this region. It was recognized early in the 1970s that the ***Gulf of Carpentaria***, a large, shallow basin defining much of the present-day northern Australian coastline, was alternately connected to the sea and isolated as a lake basin, providing a landbridge between Australia and New Guinea (Nix and Kalma 1972). However, it was not until the following decade that the stratigraphy from the basin was documented (Torgersen *et al.* 1983; De Deckker *et al.* 1988). The Carpentaria record was later extended to cover the last full glacial cycle based on multiple proxy analyses of longer cores (Chivas *et al.* 2001), the results of which have more recently been synthesized to reconstruct palaeoenvironments over the last 130 ky (Reeves *et al.* 2008).

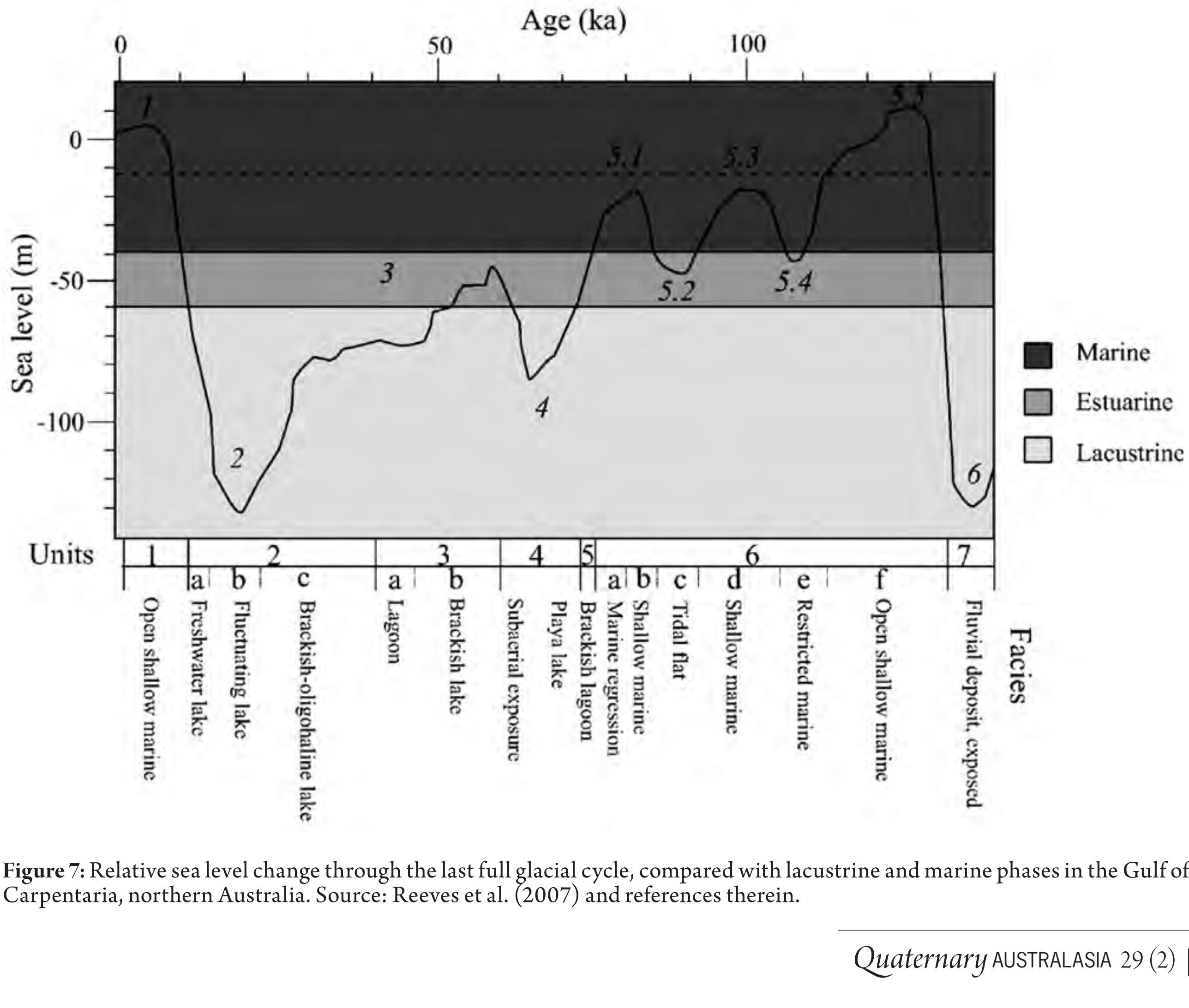

Figure 7: Relative sea level change through the last full glacial cycle, compared with lacustrine and marine phases in the Gulf of Carpentaria, northern Australia. Source: Reeves et al. (2007) and references therein.

Figure 8: Great Barrier Reef, tropical Queensland, Australia. Photo: National Geographic.

Those seeking evidence for the interdisciplinary implications of Quaternary research need look no further than the mangrove swamps of the ***South Alligator River***, which flows through Kakadu National Park in Australia's Northern Territory. Palynological and stratigraphic analyses along the floodplain of this river provided the first unambiguous evidence for substantially increased mid-Holocene mangrove swamp distribution (Woodroffe *et al.* 1985; redated to early Holocene by Grindrod *et al.* 2002), correlated with a precipitation peak and stabilized sea levels. The "Big Swamp" phase was subsequently identified across southeast Asia (Woodroffe 1993; Hanebuth *et al.* 2011). Such swamps are recognized as significant carbon dioxide reservoirs (Dommain *et al.* 2011), with attendant implications for land use and greenhouse gas release through fire and clearing. The South Alligator River cores also demonstrated the dynamism of mangrove swamps as ecosystems (Traill *et al.* 2011), and their utility as resources for Aboriginal populations (Bourke *et al.* 2007).

The largest living structure

Few would dispute that the world's largest living structure, the ***Great Barrier Reef***, is an icon of Australian ecology (and tourism!). However, less well known is that the reef, which runs half the length of the tropical Queensland coast, is a Quaternary feature, and consequently qualifies for this list. Although coral drilling to investigate reef ecosystem response to sea level change has been undertaken since the 1970s (e.g. Davies *et al.* 1988), this was generally limited to shallow depths to elucidate Holocene variation. During the last decade, however, deep drilling of the outer Ribbon Reef offshore Cooktown constrained the timing of reef initiation to the mid-Pleistocene (International Consortium for Great Barrier Reef Drilling 2001). Comparison between long cores from both the inner and outer reefs characterized the Pleistocene development of the feature (Webster and Davies 2003). It has been proposed that the Great Barrier Reef formed in response to the mid-Pleistocene onset of 100 ky climate cycles, and formed part of a global reef initiation event which held implications for Quaternary global carbon dioxide levels and temperature (International Consortium for Great Barrier Reef Drilling 2001; Webster *et al.* 2010).

The human element

The Quaternary history of Australasia can hardly be considered without acknowledging its colonization by the most successful species ever known: modern humans. Despite the relatively short duration of human occupation of New Zealand and the Pacific islands, their influence on the local ecosystems was both significant and irreversible (Holdaway and Jacomb 2000). For a long time, it was also believed that human arrival on the Australian continent was similarly recent. That is, until a youthful Jim Bowler stumbled upon an ancient ritual burial in the New South Wales outback in the 1960s, at around the same time as radiocarbon dating was increasingly being applied to the Australian landscape.

Lake Mungo, site of the earliest known ritual cremation and ochre burial (Bowler *et al.* 1970), revolutionized ideas about the antiquity of human presence in Australia. This held enormous implications for Australian society, particularly for its indigenous inhabitants; so much so that the Willandra Lakes was given World Heritage Area status in 1981. The exposure of Quaternary stratigraphy within the Lake Mungo lunette is unparalleled – dating back to before MIS 5 - and provides one of the most complete known palimpsests of archaeological traces across a landscape. Lake Mungo consequently offers a unique opportunity to investigate the interaction between humans and their environment (Bowler 1998; Bowler *et al.* 2003). The Willandra Lakes region also provides a relatively high resolution record of hydrological change during the LGM (Bowler *et al.* 2012). Arguments regarding the precise ages of the Mungo III remains aside (Thorne *et al.* 1999), the Willandra Lakes has seen some of the earliest applications of radiocarbon dating in Australasia (Bowler *et al.* 1970), as well as early novel applications of single grain OSL dating using sand preserved within the Mungo III cranium (Olley *et al.* 2006). Although other important archaeological sites have since demonstrated earlier human presence on the continent, such as ***Devil's Lair*** in southwest Western Australia (Turney *et al.* 2001), the influence of Lake Mungo and the Willandra Lakes overshadows many others as one of the most iconic Quaternary sites in our region, and remains the focus of interdisciplinary investigations.

Figure 9: The lunette at Lake Mungo, southwest New South Wales, Australia. Photo: Kathryn Fitzsimmons.

The interplay between the geological and palaeo-anthropological branches of Quaternary science continues in earnest, not least due to the recent discovery of hominin fossils at Flores within the Indonesian archipelago (Morwood *et al.* 2004), and recent high resolution work on speleothems. I propose that ***Liang Bua*** and nearby ***Liang Luar*** caves be considered some of the emerging iconic sites for the Australasian Quaternary. Out of Liang Bua, debate continues as to whether the Hobbit (*Homo floresiensis*) is indeed a new species of human (Lieberman 2009), and the site is the focus of the development of novel new applications of luminescence dating (Westaway and Roberts 2006). Liang Luar has revealed critical insights into the teleconnections between the tropics and northern hemisphere climatic events (Griffiths *et al.* 2009; Lewis *et al.* 2011). It is eminently clear from these discoveries that Australasia continues to play an important role in elucidating the tapestry of human evolution and colonization of the planet.

March of the megafauna

The 19th century fashion for identifying new fossil species penetrated even the antipodean colonies. The spread of pastoralism in Australia aided the discovery of a number of sites yielding the remains of large extinct mammalian species ("megafauna"). Debate soon raged as to whether the extinction of the megafauna was due to climate (Wilkinson 1884) or the impact of human arrival on the continent (Owen 1877). Over a century later, and despite attempts to determine the timing of megafaunal extinction across the continent (Roberts *et al.* 2001), as yet no agreement can be reached regarding its cause (Miller *et al.* 2005; Field *et al.* 2008).

Cuddie Springs, an unassuming shallow basin in northern New South Wales, is the only known site on the Australian continent where archaeological and megafaunal remains co-occur (Dodson *et al.* 1993). Consequently, the arguments for overlap between humans and megafauna, based on stratigraphy and chronology, place this site at the controversial heart of the megafaunal extinction debate. In one camp sit those contending a temporal overlap of ca. 15 ky, implying demise by climatic means (Field *et al.* 2001; Trueman *et al.* 2005). These interpretations oppose those who conclude that site disturbance caused inmixing of older (pre-human colonization) megafauna bones with younger sediments (Gillespie and Brook 2006), an argument recently reinforced by direct dating of the fossil remains (Grün *et al.* 2010). The debate, however, continues (Field and Wroe 2012).

Figure 10: *Megalania prisca* vs. *Genyornis newtonii*. Image: Peter Trusler.

The World Heritage ***Naracoorte Caves*** system, in southeastern South Australia, provides one of the most diverse megafaunal assemblages on the continent, associated with a palaeoenvironmental sequence extending back to the mid-Pleistocene (Wells *et al.* 1984; Reed and Bourne 2000). The caves first drew the attention of local priest-naturalist Tenison-Woods in the 1860s (Tenison-Woods 1862), while the earliest scientific descriptions of marsupial megafauna were made some decades later (Stirling 1908). However, it was not until the 1969 discovery of the Victoria Fossil Cave that the excellent preservation and large quantity of fossils was fully appreciated (Wells 1975). Since this time, valuable insights have been obtained into the impact of palaeoclimate on fossil assemblages (Prideaux *et al.* 2007), through correlation with long term records of precipitation from cave speleothems extending to ca. 500 ka (Ayliffe *et al.* 1998).

Fossil deposits on the ***Darling Downs*** of southeastern Queensland throw a spanner in the works of the human blitzkrieg hypothesis. Sites at Ned's Gully and within the nearby Kings Creek catchment were discovered somewhat later than the others (Molnar and Kurz 1997), but have since yielded a long and diverse record of vertebrate palaeontology, including a number of species descriptions (Price and Webb 2006). In addition, these sites have generated some of the youngest ages for megafauna on the continent (Roberts *et al.* 2001). However, chronostratigraphic evidence suggests a local decline in diversity demonstrably earlier than human arrival, suggestive of a climatic influence on megafaunal demise (Price *et al.* 2011). The extinction debate, it seems, just became more complex.

So there it is. No doubt there will be both agreement and disagreement with this (somewhat long) shortlist, more likely with respect to the exclusions than with those included. As in the case of the canon of Australasian Quaternary literature proposed in 2005 by Paul Hesse, I concede that this list of "icons" is by no means comprehensive, and there is certainly scope for more specialized catalogues, which would certainly be welcomed by the QA editorship! In the meantime, having learnt so much about these places, I am inspired to actually visit those I have yet to see in person. Field trip, anyone?

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AQUA Through The Years

To commemorate the 30th birthday of the Australasian Quaternary Association, we have prepared a collage of images from various events through the years. We hope that you enjoy spotting youthful portraits of colleagues!

Photo credits: Bernie Joyce, David Lowe, Colin Murray-Wallace, Rob Rose, Gregory Webb, and other members of AQUA.

Important milestones in the history of AQUA

1977 Jim Bowler suggests establishing AQUA through the Australian Quaternary Newsletter
1979 Quaternary field excursion to northwest and west Tasmania
1981 First CLIMANZ meeting, Falls Creek, Victoria
1982 ANZAAS Symposium on Prehistory and Environment in the Pacific Region, Sydney
1982 Formal establishment of AQUA
1984 First issue of Quaternary Australasia published (edited by Martin Williams)
1973 First issues of Australian Quaternary Newsletter published (edited by Jeanette Hope and Bruce Thom)

Fieldwork on Flinders Island, Bass Strait (1990)






AQUA biennial meeting, Myall Lakes (1989)



AQUA biennial meeting, Mallacoota (1991)




Inter-AQUA conference on tephrochronology, loess, and palaeopedology, Hamilton, NZ (1994)

An overview of AQUA meetings

1986 Mildura, Victoria, Australia
1989 Myall Lakes, NSW, Australia
1991 Mallacoota, Victoria, Australia
1994 Nerriga, NSW, Australia; also Inter-AQUA meeting on tephrochronology and loess, Hamilton, NZ
1997 Lake Eyre, SA, Australia
1999 Fraser Island, QLD, Australia
2000 Bowlerfest, Canberra, ACT, Australia
2001 Port Fairy, Victoria, Australia
2003 Westport, NZ
2004 Cradle Mountain, Tas, Australia
2007 AQUA hosts INQUA Congress, Cairns, QLD, Australia
2010 Stradbroke Island, QLD, Australia
2012 Lake Tekapo, NZ

AQUA biennial meeting, Lake Eyre (1997)

AQUA biennial meeting, Westport (2003)

INQUA Congress, Cairns (2007)

Quaternary research in New Zealand since 2000: an overview

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With the AQUA milestone of 30 years it seems an appropriate time to review the progress and achievements of Quaternary research in New Zealand. This article highlights some of the major achievements since the formal review of New Zealand's Quaternary record by Newnham et al. (1999). The focus here is on paleoclimate and geochronology and is by no means a comprehensive review. We encourage members to write future articles for Quaternary Australasia (QA) about their exciting projects to keep the wider Australasian community informed.

One of the main differences between Australian and New Zealand Quaternary science is the wide use of tephrochronology to correlate and date deposits and events across the landscape, helping to link terrestrial and marine records, especially in the North Island. There have been significant advances using glass-based fission-track dating, corrected for annealing, and the use of the electron microprobe and laser ablation inductively-coupled plasma mass spectrometry for obtaining major- and trace-element analyses, respectively, to chemically fingerprint individual glass shards in tephras to aid their correlation (Shane, 2000; Lowe, 2011). Also the identification and analysis of cryptotephras (concentrations of glass shards not visible as a layer) have greatly expanded the geographic range of many tephras, allowing the application of tephrochronology as a stratigraphic and dating tool across much wider areas than previously possible (Gehrels *et al.*, 2008).

Significant improvements in radiocarbon dating, using both liquid scintillation spectrometry and accelerator mass spectrometry, which allow for small samples and a wide range of materials to be dated (e.g. pollen concentrates: Vandergoes and Prior, 2003; Newnham *et al.*, 2007c), and robust dating of samples as old as c. 60 cal ka (e.g. Hogg *et al.*, 2007), have led to better chronological control on climatic and volcanic events. These improvements include the internationally-agreed calibration curves (INTCAL and MARINE) (Hogg *et al.*, 2009; Reimer *et al.*, 2009), and changes in the way age modelling of records is undertaken using Bayesian statistical methods (e.g. Buck *et al.*, 2003; Lowe *et al.*, 2008; Hogg *et al.*, 2009). The Kawakawa tephra, a key marker bed for the last glacial in New Zealand, has recently been re-dated using 14C and Bayesian age modelling, moving its age from c. 27,000 to c. 25,000 cal yr BP (Vandergoes *et al.*, in press). A major development has also been the update of the Southern Hemisphere radiocarbon calibration curve using a combination of dendrochronology and 14C dating of kauri and other tree rings (SHCAL04; McCormac *et al.*, 2004; Hogg *et al.*, 2011). There is now a continuous kauri tree ring record that stretches back 2000 years, which has also highlighted changes in ENSO (Fowler *et al.*, 2012). This work and other tree ring data have contributed to the Aus2K collaboration (Turney *et al.*, 2010; Gergis *et al.*, 2011).

High resolution records, dated in part using tephra and radiocarbon, have also been published from a number of lakes and bogs providing information about the last glacial cycle and the Holocene. These include records from the Auckland maars (Newnham *et al.*, 2007a; Augustinus *et al.*, 2008, 2011), Lake Poukawa, drilled as part of the PEP II project (Pole-Equator-Pole; Shulmeister and Dodson, 2002), Kaipo bog (Newnham and Lowe, 2000; Hajdas *et al.*, 2006), Okarito bog (Vandergoes *et al.*, 2005; Newnham *et al.*, 2007b), the Subantarctic islands (McGlone *et al.*, 2002; 2010), and Lake Maratoto (Green and Lowe, 1985), which has recently been selected as the Australasian auxiliary record for the "Global Stratotype Section" for the base of the Holocene, defined by the Konini tephra (unit b), and palynology (Walker *et al.*, 2009). Lake Tutira was also drilled as part of the MARGINS program, and has recorded evidence of large storms and earthquakes over the mid-late Holocene (Page *et al.*, 2010) as well as ENSO/SAM interactions (Gomez *et al.*, 2012). We would like to suggest that several of these lakes and bogs are suitable candidates for "iconic" status (see Kathryn Fitzsimmons' article – this issue), especially Lake Maratoto.

Figure 1: Lake Maratoto, adjacent to partly drained peatlands (upper part of photo) ~10 km south of Hamilton, is protected by a QE II Trust covenant (photo by David Lowe).

Detailed palynological studies over the past 12 years have increased our knowledge of vegetation succession and centennial to millennial scale changes in climate. Palynological change, together with wiggle-match dating of the Kaharoa eruption using celery pine tree-rings to 1314 ± 12 AD (Lowe *et al.*, 2002; Hogg *et al.*, 2003), also provided a date for the first environmental impacts of humans in New Zealand at c. 1250-1300 AD. Subsequent dating of exotic rat bones and rat-gnawed seeds has confirmed the timing of Polynesian settlement to c. 1280 AD (Wilmshurst *et al.*, 2004, 2008).

Another significant development in the last few years has been the development of quantitative temperature estimates from pollen using transfer functions (Wilmshurst *et al.*, 2007). Novel environment and temperature proxies have also been applied over the last decade, including using chironomid (midges) remains from lakes (e.g., Vandergoes *et al.*, 2008), phytoliths (e.g. Carter, 2002), diatoms (e.g. Page *et al.*, 2010), and coleopteran (beetle) remains from lake and soil profiles (e.g. Marra *et al.*, 2006, 2009). These temperature reconstructions, and other evidence, across New Zealand have been used to show the diachronous timing of climate events such as the late-glacial reversal, which was coincident in part with the Antarctic Cold Reversal (ACR) (Hajdas *et al.*, 2006; Vandergoes *et al.*, 2008; Newnham *et al.*, 2012).

Speleothems have continued to be exploited for their climate records. While these can be 14C dated, they can also be independently dated using U/Th, improving their chronological control. Using the micromill has also allowed sub-millimetre sampling, and the generation of high resolution stable isotope data (Williams *et al.*, 2004, 2010; Whittaker *et al.*, 2011). The stable isotopes also indicate a late glacial cool period that overlaps with the ACR and YD (Williams *et al.*, 2005). The speleothems are influenced by both temperature and precipitation and show that the last glacial maximum in the South Island was both cooler and drier than present (Williams *et al.*, 2010; Lorrey *et al.*, 2012). These findings are supported by the record of loess deposits at Ahuriri on Banks Peninsula (Almond *et al.*, 2007). This interpretation follows the publication of Almond and Tonkin's (1999) paper on sequences in Westland, which led to a step change in our understanding of the chronology and climatic significance of loess and long-range dust accumulation in New Zealand, and how soil-forming processes interact with such accumulation. Further developments have been made over the last 10 years (e.g. Lowe and Tonkin, 2010; Eger *et al.*, 2012).

Luminescence dating has become an established technique in New Zealand, although problems with dim quartz have limited the application of single grain optically stimulated luminescence (OSL). Luminescence dating has contributed to constraining climatically controlled river aggradation and loess accumulation in the North Island (Litchfield and Rieser, 2005), and to glacial chronology in the South Island (Rother *et al.*, 2010; Shulmeister *et al.*, 2010).

Figure 2: Glacial erratic sampled for cosmogenic dating, Southern Alps (photo courtesy of Alice Doughty).

There has been an enormous amount of work mapping the glacial terrains in the South Island of New Zealand over the last 12 years. A series of spectacular geomorphic maps and thorough descriptions have been produced (Barrell *et al.*, 2011). The glacial chronology has been refined mainly using 14C dates, luminescence dating, and improved cosmogenic exposure dating using 10Be, greatly aided by a new calibration for the Southern Hemisphere from a site in the Southern Alps (Putnam *et al.*, 2010a), and by the use of the Kawakawa tephra as a marker bed (Almond *et al.*, 2001; Berger *et al.*, 2002; Suggate and Almond, 2005). Cosmogenic exposure ages have confirmed the existence of ACR moraines east of the main divide (Putnam *et al.*, 2010b), but raised further questions about the age of the enigmatic and "iconic" Waiho Loop moraine on the west of the divide (Barrows *et al.*, 2007). Our understanding of what factors drive the glacial advances and retreat in the Southern Alps has also been progressed by numerical modelling work (Anderson and Mackintosh, 2006; Golledge *et al.*, 2012).

Previous reviews of the Quaternary work in New Zealand have tended to focus on terrestrial environments. Since 2000 there has been significant progress in our understanding of changes in the ocean currents and circulation of the SW Pacific. Work on long cores from the Deep Sea Drilling Program (DSDP) has continued, and has been complemented by studies on new cores drilled as part of the Ocean Drilling Program's (ODP) Leg 181 in 1998. Most recently, "Matacore", a New Zealand-France research programme, began in January 2006 during Leg 152 of the ship Marion Dufresne, which collected 31 cores around the region (Proust *et al.*, 2008). Several of these cores extend back to the Pliocene and beyond (Carter *et al.*, 2004) and have increased our knowledge of the early Quaternary, including the changes in periodicity at the Mid-Pleistocene Transition (Naish, 2005; Crundwell *et al.*, 2008). New long records of volcanic activity in the Taupo Volcanic Zone have also been developed using analyses from the marine cores (e.g. Shane *et al.*, 2006; Allan *et al.*, 2008). ANDRILL is another international programme that has provided long cores in the Ross Sea to understand Quaternary changes in Antarctica. The ANDRILL-site 1B cores have provided evidence of ice-sheet collapse during past interglacials, including most recently marine isotope stage (MIS) 31 around one million years ago (Naish *et al.*, 2009).

Figure 3: ANDRILL coring with local Quaternarists for scale (photo by Gavin Dunbar)

Suites of shorter marine cores off the east coast of New Zealand have also been studied in detail and provided information on changes in currents and circulation during the last two glacial cycles, including significant increase in ice bergs on the Campbell Plateau during the glacials (Carter *et al.*, 2002; Neil *et al.*, 2004). Cores from the Ross Sea, and on the continental shelf of Antarctica, have constrained the extent, timing and rate of ice sheet retreat at the end of the last glacial, and major retreat primarily due to increasing sea surface temperatures (McKay *et al.*, 2008; Mackintosh *et al.*, 2011).

If you were going to pick any "iconic" marine cores for the New Zealand region it would be DSDP site 594 (combined with another core taken at this same site, MD97-2120; Nelson *et al.*, 1993, 2000; Pahnke et al., 2003) east of the South Island, and P69 (and its counterpart MD97-2121; Carter *et al.*, 2002, 2008), east of the North Island. Ongoing work on these cores has provided considerable increase in our paleoceanographic understanding linked to global climate change and has helped to link terrestrial climate to changes in the marine environment, through the analyses of palynology and presence of many tephras (especially in MD97-2121).

One of the most rewarding initiatives over the last nine years has been the NZ-INTIMATE (Integration of Ice, Marine and Terrestrial records) project, part of the larger Aus-INTIMATE programme sponsored by PALCOMM and INQUA (see report by Jessica Reeves in this issue). The original poster and publications (Barrell *et al.*, 2005; Alloway *et al.*, 2007), derived from a series of workshops, were the first comprehensive attempts to compare and correlate paleo-records from a range of environments using numerous different proxies. Deposits at many of the sites were linked with tephras (Lowe *et al.*, 2008). Further work in the second phase of NZ-INTIMATE has continued to bring together new records, as well as examining the spatial variability of these records around New Zealand (Lorrey *et al.*, 2012). A climate event stratigraphy (CES) has now been erected for the New Zealand region using palynological records (Barrell *et al.*, in press). This NZ-CES paper, and several other papers dealing with climate change since c. 30 cal. ka, are being published in a special Aus-INTIMATE issue of Quaternary Science Reviews (QSR) (see report by Jessica Reeves - this issue). We encourage you to check out this QSR volume as it will provide much more detail of the latest Quaternary research in New Zealand than can be accomplished in this short review.

Along with regular NZ-INTIMATE meetings since 2004, there have been two AQUA meetings, in 2003 at Westport, and in 2012 at Tekapo. We hope the AQUA meeting will return to Auckland in 2016.

Figure 4: Participants at the 2005 NZ-INTIMATE workshop at GNS Rafter laboratories, Lower Hutt.

Peter Almond also hosted a South Island field trip as part of the INQUA Congress held in Cairns in 2007. The 'Past Climates' meeting (in association with Aus-INTIMATE) in Wellington in 2009 was a showcase for the completed glacial mapping and dating, along with progress on other New Zealand Quaternary projects, and brought together many international colleagues, and included public lectures by Profs George Denton and Wally Broecker.

So what of the future? Well, there are numerous exciting initiatives currently underway including the proposal to drill Lake Ohau with its annual depositional layers; new temperature proxy development using biomarkers such as Tex86; lots of new data are being produced from the Matacore marine cores off the West Coast; another ANDRILL core will be drilled in 2014; and increasing use of ancient DNA (aDNA) in paleocology, paleontology, and archaeology (e.g. Allentoft and Rawlence, 2012). There are also several proposals to continue the work of Aus-INTIMATE with a project called SHAPE (Southern Hemisphere Assessment of Paleo-Environments), which will include South America and Africa, and an international focus group being developed in the UK called CELL50k (Calibrating Environmental Leads and Lags over the last 50 kyr). The acclaimed annual Quaternary Techniques course run by the GNS Science National Isotope Centre for the last nine years has had an average of 30 students/year (see report in this issue by Tom Brookman). It is clear that Quaternary science is alive and well in New Zealand and that its future looks both exciting and enlightening.

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QA

An INTIMATE special issue

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As this issue of QA goes to press, hopefully so too does the Australasian-INTIMATE special issue of *Quaternary Science Reviews*. This issue showcases some of the research of the second phase of Aus-INTIMATE (INQUA: PALCOMM project #0806), which focussed on the palaeoclimate of the Australasian region over the past 30,000 years. By definition, INTIMATE looks to INTegrate Ice core, Marine and TErrestrial records and this is well reflected in the papers of this volume.

The idea for the special issue came out of the Aus-INTIMATE session at INQUA last year, "Linking Southern Hemisphere multiproxy records and past circulation patterns: Aus-INTIMATE and wider Southern Connections" convened by Tim Cohen and Drew Lorrey, which was very well represented. Ten of the papers in this volume had their genesis here. In addition, the Aus-INTIMATE group felt that we wanted a way to showcase the records we consider to be the most robust, with the intention that these would be picked up in future syntheses both throughout the Southern Hemisphere and in comparison with the Northern Hemisphere. In part, this volume is a vehicle to achieve this.

The special issue includes a combination of synthesis papers and more localised records. The syntheses have been achieved through large collaborative efforts. Papers include a revision of the terrestrial composite stratotype for New Zealand (Barrell *et al.*), a time-slice analysis of the Last Glacial Maximum vegetation in New Zealand (Newnham *et al.*) and re-analysis of glacial records of the Southern Alps by glacial modelling (Doughty *et al.*) and refined chronostratigraphy of the West Coast (Barrows *et al.*). The review of the Southern Ocean records (Bostock *et al.*) includes both the Australian and New Zealand sectors (actually 180º of longitude!) and sea-level change in Australia since the deglacial is compiled (Lewis *et al.*). Other regions of Australia are dealt with in the temperate (Petherick *et al.*), tropical (Reeves *et al.*, b) and arid interior (Fitzsimmons *et al.*) papers and brought together in the Australian region synthesis paper (Reeves *et al.*, a).

Other papers focus on key, high resolution sites that fit into the overall remit. In many cases, these records are critical to the regional syntheses outlined above. These records include the vegetation work from Stradbroke Island (Moss *et al.*), Howard Valley (Callard *et al.*) and Galway Tarn (Vandergoes *et al.*, b) and the speleothem record from Flores (Griffiths *et al.*). Two issues of chronology are also dealt with including a refinement of the age of the infamous Kawakawa tephra (Vandergoes *et al.*, a) and a revision of the timing of the late glacial reversal at Kaipo Bog (Lowe *et al.*).

Part of the remit of the Aus-INTIMATE project was to establish climate event stratigraphies (CES) for the Australasian region to enable comparison with the North Atlantic INTIMATE group. It may be argued that strictly speaking we have failed in this endeavour. Particularly for Australia, our compilations find few climatic events that could be used to construct such a CES that would be representative for the region. Even the New Zealand group, with their substantial glacial evidence, well-behaved lake records and conveniently placed tephras have found this a challenge. What we have achieved though is a community approach to regional syntheses which highlight our most reliable records and go some way to understanding why and how the regions respond differently to changing boundary conditions.

To highlight the collegiate nature of this project, just short of 100 (98) individual authors contributed to this volume. Tim Barrows takes the title of INTIMATE King, being involved in seven manuscripts, closely followed by Marcus Vandergoes and Rewi Newnham on six. David Barrell is also well represented, with five papers. Helen Bostock, Tim Cohen, George Denton, Kat Fitzsimmons, John Jansen, Patrick Moss and I kept busy, contributing to four each. A total of 41 reviewers also made insightful comments on the manuscripts.

Now that phase II has come to a close, the Aus-INTIMATE steering group will be proposing a new project to PALCOMM: SHAPE (Southern Hemisphere Assessment of Palaeo Environments) with Drew Lorrey, NIWA, NZ as project leader for the next inter-INQUA Congress period. SHAPE will incorporate the other Southern Hemisphere nations and will look further back in time to early MIS 3 (~60 ka). Data-model integration will be a major component of SHAPE, along with targeting of key sites for proxy-based studies. Aus-INTIMATE has been approached by the COST-INTIMATE group to suggest that SHAPE sit within a new INQUA International Focus Group (CELL-50k) led by that Simon Blockley.

Details of this will be discussed at a planning meeting in Budapest in November, including an INTIMATE session at the next AQUA biennial meeting.

I would like to thank all of the researchers who have been part of this exercise. Firstly, those in OZ who attended the AINSE meetings and responded to my emails; particularly those who led the regional groups and brought the syntheses together. Secondly, my kiwi colleagues who I have come to know and love through my seemingly annual trips to NZ to report on progress. Thirdly, Tim Barrows and Brent Alloway who were co-editors on this volume. It has been a difficult task managing so many papers and particularly finding enough suitable reviewers.

But let's go back a few steps. Back in May 2009, Tim Cohen and myself accepted a "free ticket" to attend the Past Climates meeting in Wellington, sponsored by Aus-INTIMATE and the CcASH project facilitated by the Australian Nuclear Science and Technology Organisation (ANSTO). After a couple of days of entertaining talks and poster presentations, we attended the business meeting to discuss the future of Aus-INTIMATE and, in particular, the engagement of researchers in Australia. After some comments by David Fink and Patrick De Deckker, Tim and I exchanged glances and shifted awkwardly in our chairs, as the moment of truth dawned. This was the price of the ticket.

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QA

Science meets Parliament 2012 Canberra, Australia 17-18th September 2012

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Summary

Science meets Parliament (SmP) is an annual two day event in which scientists from a variety of disciples descend on the capital to learn about communicating their work with both the public and politicians, and to discuss their work in small group sessions with Members of Parliament. It is an opportunity for early career researchers to broaden their network and talk about their work, and for both ECR's and more experienced researchers to explain the significance of their findings to those who examine funding and determine policy that should be based on these findings. This year SmP coincided with the launch of the bipartisan Parliamentary Friendship Group for Science and the distribution to parliamentarians of "The Geek Manifesto" which discusses the significance of science in society. The central theme was effective communication.

Monday, 17th September

Day 1 of Science meets Parliament 2012 was at the National Gallery, and proved to be both informative and entertaining. This year Jessica Reeves (University of Ballarat) and I were representing AQUA, although other members, Patrick Moss (University of Queensland, Science & Technology Australia (STA) board member) and Pia Atahan (Australian Nuclear Science & Technology Organisation), were also present.

The day began with addresses from Professor Michael Holland, President of STA and Anna-Maria Arabia, CEO STA, and organiser extraordinaire. When our attention was drawn to the bundle of coloured paper cards on the table with which we would participate in a bonding activity, a few eyebrows were raised. The game was aimed at examining the direction of influence between key players in science and politics including the Australian people, senators, MP's, the media, lobby groups, advisors and more, and provoked enjoyable contemplation and conversation (Figure 1). Some key points raised included that many relationships appeared to be based on unidirectional influence, the media were seemingly at the centre of everything, the difference between ideal versus actual flows of information and influence and the discussion of who were the scientists in this break-up. Ideally, our group thought scientists should be advisors, but perhaps they more often fall into the categories of public servants and interest groups in practice.

It is this problem that led to "the Geek Manifesto" being penned, which examines the significance of science in politics and policy. STA recently ran a program where members of the public could buy a copy and nominate the politician who would receive it, and during SmP these copies and letters were delivered to all Members of both Houses. This is critical timing as there is discussion regarding the role of Science in Evidence Based Policy at the moment in the Australian Public Service. One of the key factors highlighted regarding how science and policy interact was that of timing. This was both in the sense that politicians and scientists work on very different time scales, and that of the timing of discoveries in relation to political events. An example of the latter is that an announcement on the findings of GM foods and health was being made and not a single journalist was there to cover it as news had leaked of the announcement of the most recent leadership challenge within the Government (Rudd-Gillard). Patricia Kelly sees that the situation should be "a systematic evaluation of available information (with) the right advice from the right people at the right time". Although the timing of break-throughs cannot be timed to fit current affairs, we still need to ask ourselves in general where it is that we are going

Figure 1: Jessica Reeves and Stephanie Kermode examining who influences who in Australian politics. Photo credit: Lorna Sim, Science and Technology Australia.

wrong when trying to communicate our message. Perhaps if we were doing a better job of communicating the significance of what we do, the numbers of upper high school students studying science would not be in decline; an issue identified by Chief Scientist of Australia, Ian Chubb. If we engage the imagination of the public, science would not seem as something done only by people with a fondness for white coats, but the relevant, useful and rewarding career path that it is.

On this note, we also had an address from Professor Graham Durant AM, the current Director of Questacon. He gave practical advice and ideas about how we should be engaging the public and the politicians. Points of emphasis were to include a good, descriptive picture and to remember that exposure is the key. National Science Week this year substantially raised the profile of science with 676 media reports which equated to $1.5 million worth of advertising. He proposed that we better utilise the occasional paper series, which originated in the UK parliament, to disseminate and contextualise the critical aspects of our findings. After all, research isn't the only sector which would benefit from more money, but without an understanding of what we do and why, it is difficult to expect policy makers to prioritise research funding.

Following morning tea was a media session, "Meet the Press". The panel included Lyndal Curtis (radio), Phillip Coorey (print), James Massola (online) and Mark Riley (television). The journalists were informative, detailing how different aspects of the media work, and how best to pursue each of them. Essentially, given the lack of profits in news in the current (world), most outlets are understaffed, regardless of area, and if approached are generally responsive, particularly if the information is well presented and framed. Unfortunately, due to these same staffing cuts, dedicated science journalists no longer exist. This is an alarming thought, because publicising our work enables the public to see how important it is, and this in turn signals that it should be funded to politicians.

On this note, the afternoon's sessions were a little more interactive, and included a session on setting up and using Twitter, and a session to prepare a 30 second pitch (for which there were play-offs and a prize). These sessions were run by Dr Will Grant and Dr Rod Lamberts from the Centre for the Public Awareness of Science and Dr Kristin Alford from Bridge 8 Pty Ltd. The Twitter session got off to a poor start when the wrong WiFi password was announced and only those with hotspots for their gadgets had internet access. Fortunately those with hotspots were those who had Twitter already, so the live Twitter feed kept us amused. The stage screen showed Jasmin Craufurd-Hill (ANSTO, @jasminchill) tweet "We can operate accelerators, telescopes and nuclear reactors, just don't try and get us to use twitter with WiFi" to the amusement of all. The 30 second pitch was a useful exercise as, being timed, forced us to distil our thoughts with clarity and purpose. It was also a pleasant way to hear about the exciting research being conducted by those in the room, from city-scale energy modelling to leukaemia research to earthquake labs to productivity as a function of office temperature. Of particular interest to me was the 'earthquake lab' that Associate Professor Tim Rawling (AusScope, University of Melbourne) is proposing, in which they find a remote part of Australia and make little earthquakes in order to study them (n.b. this is distinct from fracking).

As the events of this day were to prepare us for our meetings on the next, we were given a running list of "Do's and Don'ts", including a session specifically on this topic. This session was run by Dr Richard Dennis of the Australia Institute and Kylie Walker, Director of Communications and Outreach for the Australian Academy of Science, although the 'Twitter team' also conveyed similar points. The first and most important rule, which was very heavily emphasised, is that we should not argue with the politicians or with each other during the meeting. If they were in fact wrong, we should not point this out, but we should explain the truth to them. In terms of conveying our pitch or message, we should have one or two key points only. We need to be clear and concise in relaying these, and the best way to make sure the message hits home is to put it in the context of their life. Telling a story was recommended as it makes the information easier to remember, automatically contextualises the information and also entertains (which means they might actually pay attention). People left Gandell Hall that afternoon abuzz, off to prepare for the grand evening event.

The Gala Dinner in the Great Hall was a sophisticated affair (Figure 2), and provided a further opportunity to meet other scientists, media persons and politicians. In fact it was probably the most valuable time to engage the politicians who were present. This was particularly true as they had just received a crash course in astronomy from Brian Schmidt on the roof of Parliament House; I was a bit jealous that the scientists weren't invited! The evening served as the occasion to launch the bipartisan Parliamentary Friendship Group for Science, following a keynote address from Senator the Honourable Chris Evans, Minister for Tertiary Education, Skills, Science and Research. However it was Anna-Maria Arabia who stole the show with her message that changing your mind as new evidence becomes available is "not a back-flip, it is leadership", and that we scientists will support you in this.

Figure 2: Stephanie Kermode and Prof Brendan Kennedy (President of AINSE, University of Sydney). Image credit: Lorna Sim / Science & Technology Australia.

Tuesday, 18th September

Day 2 brings the essence of Science meets Parliament, where the majority of meetings between scientist and MP's occur. The day began with an address from the Honourable Mark Dreyfus (member for Isaacs, Labor) in the absence of the Prime Minister who was attending a military funeral, and Greg Combet AM MP, Minister for Innovation and Industry, who had broken his ribs. His talk centred on how science has, and will continue to, underpin the prosperity of Australia. While ranking high globally in terms of science literacy, we have slipped from 3rd in 2000 to 7th today. This decline in general understanding of science and its significance could adversely affect our capacity as a nation to develop an innovative economy. Of particular concern to him is the lack of collaboration between science and industry. Our economy is strong, even in this precarious global financial environment, and has grown every year for the past 21 years. He believes that better linkages between science and industry, as well as continued investment in science, are critical for the maintenance of Australia's wealth.

The morning for me was fairly relaxed as my meeting was not until 1pm, and was spent with my group preparing for the meeting ahead. The chatter was focused on finding out our commonalities and deciding on things we might like to say about science, or about careers within science. With three young women in the group, one message discussed was the competing priorities of careers and families, and the difficulties of this in a career which is highly competitive and based on output and frequently short-term contracts.

Following morning tea, the Honourable Chris Evans, Minister for Tertiary Education, Skills, Science & Research participated in a Q&A session. The first question was from the accelerators group at the ANU regarding operations funding. Minister Evans acknowledged that it is an issue in research funding that operations budgets are often not included in the equipment grant, or the total grant request is not fully awarded and this section of the budget suffers. An operations budget seldom exists in a meaningful long-term capacity, nor is there provision for maintenance and upgrading of facilities built into funding strategies. Long-term funding and investment, as well as employment continuity were touched upon in other comments also. Terry Rankin, CSIRO, questioned the wisdom of setting up large scale infrastructure without first having developed the research capabilities (particularly personnel), so that equipment can be fully utilised from the point of commissioning. To this the Minister essentially replied that this is up to the management of CSIRO and relevant institutions; Ministers should keep their noses out.

Following this, available participants departed for the National Press Club for the address from Professor Brian Schmidt, Nobel Laureate 2011. His Nobel Prize in Physics was awarded for his breakthrough in determining that the rate of expansion of the universe is increasing. I was unfortunately unable to attend, as my meeting was scheduled during that period. Nonetheless, his speech from this event can be found on The Conversation – an independent source of reporting from the research sector. He spoke passionately about the importance of spending money on education, particularly in the science realm, but also the importance of funding our universities to make them rank with the best globally - stating we should aim to have one university in the top ten globally, and three in the top fifty. Again the theme of timescales was raised; research does not follow the three year election period. Nonetheless, every government (including members of the opposition) should be aiming for the economic and social prosperity of their country, and science is the platform on which this can be guaranteed in the long term. Hopefully this message is reaching our politicians.

My meeting was with Tony Zappia, Member for Makin, Labor Party. This electorate is in north-west Adelaide, and being at the end of the Murray-Darling is very sensitive to issues about water, in terms of allocations, environmental flows, climate change and as a critical resource. Our group was therefore a focus group rather than an array of scientists, all with interests in facets of water management. Members of the panel included Dr Lyndsey Vivian, a post-doctoral fellow at CSIRO who is currently examining the ecology of floodplain wetlands; Dr Sondoss ElSaawah of the ANU, who develops decision support and assessment models for water resource management; Declan Clausen, Catchment Management Officer for the Hunter Water Corporation and an Environmental Engineering student; and myself, a fluvial geomorphologist examining the response of the Shoalhaven River to changes in climate and associated factors at a variety of time scales. This alignment of the politicians' areas of interest and the expertise of the scientists with which they meet is by design. The program works by the MP's selecting areas relevant to their portfolio, electorates' requirements or even personal interests, and meetings are allocated based on the scientific resumes provided to the organising committee. During our meeting we discussed the work that each of us was currently doing, and how this related to Tony's electorate, and then answered questions before opening into a more general discussion of resources and striking a balance with environmental base-line requirements. The session went for just under an hour, although as it was immediately before question time, our chat had to come to an end in order for us all get to the gallery.

Question time was, in terms of behaviour, exactly as it is depicted on television, if not worse. Much of the 'debate' was actually about jeering and point scoring, without generally any constructive advances on the issues in question. Exciting for science was that Adam Bandt, (Member for Melbourne, Deputy Leader of the Greens) used his fortnightly question to ask the government to promise to protect NHMRC and ARC funding. His Tweet later covered the situation in a nutshell "Treasurer refuses to guarantee NHMRC/ ARC grants in search for budget savings. Sacrificing science for a surplus isn't worth it". The rumour mill at the Capital has it that the government may suspend the next two rounds of ARC and NHMRC grants for six months, effectively bypassing a round of this critical funding in the short term. However there was considerably more time spent on looking at the budget, and accusations of lying by both sides, and a very frustrated Speaker of the House standing up on several occasions to silence those present.

A more pleasant banter was present at the cocktail finale of SmP, which was hosted by The Greens. An agreeable way to end the two days, it was attended by Greens members Adam Bandt, Sarah Hanson-Young and Christine Milne amongst others, and provided an opportunity to both consolidate new scientific relationships, as well as a final, less formal chance to talk to politicians about what matters to us. It was very refreshing when chatting to Sarah Hanson-Young to hear her frustration at the Murray-Darling Basin Plan in terms of its inadequacy in addressing key issues identified by the scientific studies. Her primary concerns were that the allocations fall well short of recommendations (less than 1/3 of environmental flow requirements), and that the plan is then locked in for ten years, regardless of how the system is responding or what climate fluctuations occur. This was in stark contrast to an MP from another party who boasted about the fact the Murray-Darling Basin Plan ignored all of the science and adopted virtually none of the recommendations. Let's hope that opening the lines of communication and utilising avenues to engage the public with the science will limit the frequency of the latter example occurring in the future.

QA

The 9th GNS Quaternary Techniques short course: Techniques of palaeoclimatic and palaeoenvironmental reconstruction, measuring change and reconstructing past environments

National Isotope Centre GNS, Lower Hutt, New Zealand, 17–18 May 2012

Judith L. van Dijk [a] and Scott Sharp-Heward [a]

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Wednesday evening, May 16, the airplane from Christchurch lands nicely on time in Wellington. A shuttle takes us to a hostel near the train station. We quickly take our luggage to our rooms and head to the station to check the timetable for trains to Lower Hutt the next morning. We have a wee walk around downtown and settle into one of the nice bars for a variety of Belgian Beers. Being from Christchurch we're not used to having a city centre, and being able to choose between bars that are all in walking distance was a real treat! For a few moments we pretended we were simply in Wellington to soak up some culture and tasty beer, but soon bed called our names and reminded us of the early morning train ride the next day!

Thursday morning a mix of 35 students, researchers, analysts and technicians climbed the hill on Gracefield Road in Lower Hutt to attend the 9th GNS Quaternary

Techniques Short course at the National Isotope Centre. (Not us though, we took the wrong train, got stuck at a dodgy train station, missed the bus and had to take a cab to be at GNS in time…we were dropped off on top of the hill and saw the other attendees climb it.) All having an interest in Quaternary Science, the variety of fields represented was broad and included geologists, DNA-specialists, archaeologists, geographers, geomorphologists, volcanologists and soil scientists. The New Zealand universities represented included Auckland, Canterbury, Lincoln, Otago, Victoria and Waikato. There even was an attendee from Adelaide, Australia, working with Flinders University and the South Australian Museum. Presenters were representatives of NIWA and of course GNS.

Only a few people did not know anyone when they arrived, but before the day even started that was solved over a cuppa in the tearoom. It seemed to be a get-together of colleagues and friends from different universities. Research interests were shared, the program was discussed and many mini-meetings were organised for the two days to come. Most of the talk that morning discussed what's new in the world of Quaternary Science. The program promised to be an intensive workshop on techniques presented by experts in their fields of research.

At 9 o'clock, the program started with a general introduction on why we should study the Quaternary. An interesting question, since outside of work it isn't always easy to explain in a simple way why we do what we do. Rewi Newnham explained it exceptionally well! Quaternary science really arises from an interest in learning what happened in the past, but it is equally clear that we are living in the Quaternary. The patterns and processes derived from palaeoenvironments, and their impacts on the future, are becoming more important every day.

The hour that followed was not nearly enough to cover the applications of radiocarbon dating and the importance of improving techniques, calibration and interpretation (Christine Prior and Bruce McFadgen). It was good to know that there was morning tea ahead, which created some time to ask further questions. All breaks in the program were efficiently used for this purpose, simply because when you assemble a bunch of scientists there is never enough time for discussion!

During the rest of the day the basic principles of proxy records were discussed, including the application of marine and terrestrial microfossils as proxies for past environments (Guiseppe Cortesse and Marcus Vandergoes respectively). The focus was on the use of modern analogue datasets, with a strong emphasis on determining the most important factor influencing the fossil assemblage in one's study area, and how sensitive species are to these factors. These questions are applicable to any proxy record, not just fossil assemblages. Another very important principle was the disruption of the fossil record, and how this can be identified in some proxies but not in others. The important message was that one should always aim for a multi-proxy approach.

Lectures were followed by laboratory tours. Here, methods for microfossil extraction were explained and several types of microfossils were displayed; distinguishing between species was discussed by Sonja Fry and Giuseppe Cortese. After a lovely lunch in the sun with a view over the harbour it was hard to return to the lecture room, but we were soon discussing the importance of basic geological principles in the context of stable isotope research (Kevin Faure, Karyne Rogers and Helen Neil). Kevin Faure stated that there is nothing on earth that we cannot apply stable isotope chemistry to, as long as we understand the fractionation processes.

After afternoon tea, we discussed the sensitivity of proxies to different factors, with reference to multi-proxy case studies of palaeostorm reconstruction and palaeotemperature indicators based on carbonate precipitates (Mike Page and Joel Baker respectively). We then split into two groups for a tour of the radiocarbon and stable isotope laboratories and a demonstration of coring equipment. It is one thing to know what to do with a record, another to know how to retrieve one.

After having had a look around the premises we were all ready for some refreshments, during which all attendees spent two minutes to introduce their research interests. Sharing this information lead to a very talkative evening during which a great dinner was served.

Friday morning started with another early morning train ride up the Hutt Valley, with our more fine-tuned approach to getting off at the right station saving much time. After a brief shortcut and some bush-bashing we arrived once more at the GNS

Figure 1: One of the many informative laboratory tours of the GNS facilities (Photo by Margaret Low).

National Isotope Centre. This day again promised to be both highly informative and comfortably informal.

Clutching precious caffeinated concoctions we made our way into the lecture room. Bob Ditchburn discussed 137Cs and 210Pb in dating, two unstable isotopes produced by atmospheric nuclear testing in the 1950s and 1960s, leaving useful peak concentrations in sediments. This technique has been used effectively in erosion studies in New Zealand. Nicolas Rawlence followed on the uses of ancient DNA in reconstructing Quaternary environments. I have never heard so many coprolite jokes in one presentation and special note must go to Nicolas' tongue-in-cheek t-shirt: "We have the fossils. We win." The following presentation by Uwe Rieser on optically stimulated luminescence dating was a good introduction to the subject and enthusiastic questions followed the talk.

After another delightful morning tea break we resumed the day's talks with "stable isotope analysis in ice core paleoclimatology," which discussed ice coring and the application of Deuterium and 18O isotopes. Next was a tour of the XCAMS (accelerated mass spectrometry) facility, where New Zealand's radiocarbon dating is carried out; a real highlight thanks to Albert Zondervan. This was followed by a tour of the ice core facility (quite chilly at -35˚C) by Nancy Bertler, after which the lovely sunny weather was even more appreciated over another tasty lunch.

The first talk after lunch is generally known to be a hard sell, but David Lowe did very well with his talk on the applications of tephrochronology, with plenty of room for questions. A little behind schedule, Andrew Lorrey from NIWA continued with discussion of the advantages and disadvantages of dendrochronology. The next talk was from Chris Moy, discussing the use of isotopes from lake sediment records. Chris Norton closed the first afternoon session with an informative lecture on cosmogenic nuclides. Well behind schedule there was little time for afternoon tea, and we were back in the lecture room for the final session.

This began with an excellent presentation by Andrew Mackintosh on climate reconstruction from glaciers, summarising glacial geochronology and models of glacier expansion and retreat. The final talk of the afternoon was on isotope pedology and soil interpretation by Troy Baisden. This talk was very interesting to us soil scientists. A quick summary and closing of the course followed, and just like that the program was over!

The program was an intensive workshop in specialized techniques presented by experts in their own field of research. It lived up to expectations. Most of the techniques were not entirely new, but they have developed substantially through improvements in methods, calibrations, and understanding of factor-sensitivity of proxies, and in our understanding of geological processes. Statistical analyses are now more widely used. You could say that there are two equally important sides to Quaternary science: dating and proxy interpretation, and both sides were covered in greater detail than one could expect in a two day course. Furthermore, the importance of fundamental principles was reinforced during the course.

On Friday evening most attendees lingered for drinks and nibbles. Everyone seemed to be convinced that the registration fee was fair, considering that we had two worry-free days of ample food and drink. We were taken good care of, the speakers were magnificent and when unintended drowsiness kicked in, a break was never far away. Big thumbs up and many thanks to the organisers of the course: Christine Prior, Karyne Rogers and Marcus Vandergoes.

QA

Figure 2: Collection of speakers and attendees at the GNS Quaternary Techniques Short Course 2012 (Photo by Margaret Low, GNS).

IGC Brisbane August 5-10, 2012

Joe Prebble
Antarctic Research Centre, Victoria University and GNS Science, Lower Hutt

The International Geological Congress has met approximately every four years since 1876, and its 34th meeting was held in Brisbane in August 2012.

It's a big meeting, with over 6000 delegates, who presented more than 3700 talks and 1500 posters to almost 200 symposia over five days. These symposia covered a wide range of earth-science related topics, from Archaean mineral systems, to radar in planetary exploration, to submarine archaeology, to name a few. While symposia were carefully arranged into themes to minimize conflicts, such a large volume of interesting science over the week required numerous trade-offs between fascinating concurrent sessions!

Quaternary research was well represented. There was a strong Australasian and Antarctic flavour to many of the presentations, which were nicely balanced by some key contributions from other global records.

Personal highlights (with no attempt to cover the full range of Quaternary-related offerings!) included the session on warm climates in the Quaternary, which included marine and terrestrial records from the Pacific, ice records from Antarctica, and a keynote presentation from Dorthe Dahl-Jensen of new MIS5 results from Greenland Ice drilling.

Another session on sea level and general paleoceanography had very good presentations, including isotopic tracers of glacial water mass characteristics, and was launched with a presentation by Eelco Rohling, who introduced new temporal control to the Red Sea level records.

A session addressing dating our recent past, and analytical methods in Quaternary geochronology and paleoclimatology, provided broad interest to the Quaternary community on the application of and methodological improvements for a number of dating techniques including U-Series, luminescence and electron spin resonance (ESR) dating.

Two sessions were dedicated to results from the Integrated Ocean Drilling Program (IODP), and contained a series of interesting new data from both the Australasian region and further afield, including new stratigraphic control from the 2009 Canterbury Basin cores (Exp 317), timing of the development of the Great Barrier Reef (Exp 325) and two very interesting talks on the late Quaternary variation of the Mediterranean outflow, seen from contourite deposits in the Gulf of Cadiz (Exp 339).

There was also a series of very interesting presentations focused on Antarctic and Southern Ocean records, including ice shelf stability during the Holocene, new results on Plio-Pleistocene ice sheet variability from the Wilkes Land Margin (also an IODP expedition, Exp 318), LGM estimates of sea ice extent south of Australia using diatom-based transfer functions, and some useful overview presentations on longer-term

Photo: Speakers at the opening ceremony liked their presents.

Antarctic climate variability during the Cenozoic, including Eocene – Miocene marine records from Wilkes Land, and refinement of interpretation of the sparse Miocene vegetation records from the Antarctic dry valleys.

There were particularly good plenary sessions over the five days, with two to three speakers presenting around a theme for an hour before each lunch break. Three of these stood out. In the first, the scale of the increasing demand for resources was presented from three contrasting points of view: an academic researching water supply, an executive from a global mining company Vale, and Mr Xu Shaoshi, the Minister of Land and Resources of the People's Republic of China. Having presented some of the problems and scale on the first day, the second plenary was focused on one aspect of the tension of resource demand, with a plenary entitled 'hydrocarbons in a carbon constrained world'. This contained three very good talks from Lord Ron Oxburgh (former chairman of Shell) on the scale and timing of response required for climate change, from Scott Tinker (state geologist of Texas) on the revolutionary impact of shale gas on the American, and global, gas supply and possibly carbon emissions (followed up by a movie on the same subject, in which he starred; that was shown during an evening later in the week), and Sally Benson (Stanford University) on the scale and requirements of carbon capture. Finally, a plenary session on climate signals from the geological record presented by Tim Naish (Antarctic Research Centre, Wellington), and Will Steffen (ANU) neatly combined data from many of the other sessions I had been attending throughout the week.

A large trade show, called the GeoExpo, was also associated with the conference. This had over 120 exhibitors and included representatives from national geological surveys, resource companies, professional organisations, publishers, and suppliers of specialist equipment and technology. Plenty to see, including the opportunity to get up close to some local wildlife in the form of snakes and young crocodiles at the Vale booth!

The conference was well run - despite the large number of people, there was even unused space in the massive Brisbane Convention Centre! - the weather most agreeable, the catering excellent, the presentations thought-provoking and the company superb! Large boots to fill for the next meeting of the IGC in South Africa, 2016…

QA

Photos: Credit IGC conference organisers. Right: delegates at the welcome reception. Bottom left: The Vale sponsored sand sculpture changed daily. Bottom right: There were stilt walkers, no idea why.

ARC results

Congratulations to the latest recipients of the recently announced Future and Laureate Fellowships, and Linkage grants. Here is a summary of those projects related to Quaternary research, including archaeology.

FUTURE FELLOWSHIPS

The Australian National University

FT120100716
Bedford, Dr Stuart H
The archaeology of ritual architecture on the islands of Malakula, Vanuatu
Total $711,333.00, ARCHAEOLOGY
This project will define the historical trajectory, function and role of ritual architecture across Malakula, Vanuatu, furnishing crucial comparative data and contributing to debates on the dynamics and manifestations of long-term social changed across the Pacific. Contemporary issues such as population growth, land and food security will be addressed.

FT120100757
Cameron, Dr Judith A
The Maritime Silk Route as a world system
Total $645,273.00, ARCHAEOLOGY
New archaeological evidence suggests that cultural interaction along the Maritime Silk Route was more complex than previously held. By using new analytical techniques to source artefacts from pre-Oc Eo sites in South Vietnam, this project will provide new insights into the production and distribution of trade goods 2000 years ago.

FT120100842
Hogg, Dr Andrew M
Dynamics of the Southern Ocean
Total $780,675.00, OCEANOGRAPHY
The Southern Ocean is critically important to future global climate: it controls the natural global carbon cycle and the distribution of heat and nutrients around the ocean. This project will investigate key uncertainties in the Southern Ocean's response to climate change, and thereby improve our capacity to predict future climate.

FT120100299
Oxenham, Dr Marc F
Origins, health and demography of ancestral Southeast Asians: 2500 BC to 1000 AD
Total $708,777.00, ARCHAEOLOGY
This project will investigate the origins, demography and health of ancestral Southeast Asian peoples, particularly during and after the Neolithic revolution. This crucial and transformative period in prehistory ushered into Southeast Asia the first farmers, novel technological changes, waves of new migrants and hitherto unknown diseases.

FT120100241
Sidwell, Dr Paul J
Unlocking the missing Millennia of mainland Southeast Asia
Total $682,460.00, LINGUISTICS
This project will reveal the prehistoric transition from Neolithic to Bronze Age in South and Southeast Asia, the missing Millennia of the archaeological record. Sophisticated linguistic analyses, facilitated by innovative computational methods and bioinformatics, reconstruct the languages, migrations, and societies of the region's oldest cultures.

Macquarie University

FT120100440
Handley, Dr Heather K
The timescales of Earth-system processes
Total: $621,746.00, GEOCHEMISTRY
This project will advance our understanding of the timescales of Earth processes using short-lived (22 to 380,000 years) isotopes. The results will provide better constraints on the timescales of magmatic processes and frequency of large-scale eruptions for volcanic hazard mitigation and also soil production rates for landscape erosion studies.

FT120100462
Jacob, Dr Dorrit E
A new approach to quantitative interpretation of paleoclimate archives
Total $822,007.00, GEOCHEMISTRY
Skeletons of marine organisms can be used to reconstruct past climates and make predictions for the future. The precondition is the knowledge of how climatic and environmental information is incorporated into the biominerals. This project will use cutting-edge nano-analytical methods to further our understanding of how organisms build their skeletons.

The University of New South Wales

FT120100168
Curnoe, A/Prof Darren K
Human dispersals and the early peopling of East Asia and Australasia
Total $800,519.00, ARCHAEOLOGY
This project will address the most important question of contemporary human evolution research - the origin of modern humans - targeting evidence from ancient fossil humans through virtual anthropology techniques, human ancient DNA sequencing, and

cultural evidence in the vital but poorly known East Asia region, focusing on China.

FT120100004
Fogwill, Dr Christopher J
Understanding the drivers and impacts of long-term Antarctic ice sheet change
Total $672,342.00, PHYSICAL GEOGRAPHY AND ENVIRONMENTAL GEOSCIENCE
This project will extend historical records of change and develop an understanding of the complex linkages between the climate and Antarctic ice sheet dynamics. The results will thereby assist in identifying the mechanisms of the past and future ice sheet stability and be communicated to the general public by enhancing scientific understanding.

La Trobe University

FT120100399
Herries, Dr Andrew I
A new chronological framework to access regional variability in mid-Pleistocene archaeological, palaeo-ecological and palaeoclimatic data from Africa
Total $795,965.00, ARCHAEOLOGY
This project will enable us to understand, for the first time, the contribution of South Africa to human origins between 1.8 and 0.6 million years ago. It will help us understand how major changes in climate have influenced our evolutionary history, the animals around us and how our behaviour and tools have changed to adapt to such changes.

The University of Melbourne

FT120100715
Baker, Dr Patrick J
Climate-proofing southeastern Australia's native forests: where, when, and how?
Total $683,974.00, FORESTRY SCIENCES
Changing environmental conditions and forest fragmentation threaten the ability of native forest species to regenerate or migrate. Using unique long-term datasets and novel statistical analyses, this project will assess future risks to forest regeneration after logging, bushfires, and land abandonment.

James Cook University

FT120100656
Ulm, Dr Sean G
Resolving fundamental problems in the dating of marine shell in the tropics
Total $699,593.00, ARCHAEOLOGY
This project will model variability in the way carbon is distributed in marine environments and animals in tropical Australasia. Results will provide key enabling tools for accurate dating of marine materials, realising the potential of previous research and forming the basis for accurate reconstructions of cultural, sea-level and climate changed.

University of Tasmania

FT120100759
Chase, Dr Zanna
Southern Ocean oxygen variability since the last glacial maximum
Total $706,046.00, OCEANOGRAPHY
Recently observed decreases in ocean oxygen concentration could decrease ocean biodiversity and accelerate climate change. This project will determine the links between climate change and ocean oxygenation since the last ice age, and provide a way to predict future oxygen concentrations.

LAUREATE FELLOWSHIPS

The University of Western Australia

FL120100049
McCulloch, Prof Malcolm T
A new paradigm for quantifying the resilience of marine calcifiers to ocean acidification and global warming
Total $3,229,566.00, GEOCHEMISTRY
This multi-disciplinary research project will determine the future of coral reefs and marine calcifiers in response to rising carbon dioxide and ocean acidification. This will enable best-practice adaptive management at local and regional-scales for marine-dependent industries, and provide new hope for some of our greatest natural assets, coral reefs.

The Australian National University

FL120100156
O'Connor, Prof Susan L
Understanding modern human dispersal, adaptation and behaviour en route to Australia
Total $3,147,123.00, ARCHAEOLOGY
This project will investigate modern human dispersal, adaptations and behaviour along the maritime route to Australia. Using strategic testing of archaeological and biotic deposits, museum collections and predictive modelling, it will help us understand the unique adaptive and cognitive abilities that were required to make this journey.

FL120100050
Rohling, Prof Eelco J
Sea level change and climate sensitivity
Total $3,079,069.00, PHYSICAL GEOGRAPHY AND ENVIRONMENTAL GEOSCIENCE
This project will aim to improve understanding of climate and sea-level change on timescales relevant to longer-term planning, by characterising the relationship between past sea-level/ice-volume change and other key climate factors such as temperature and greenhouse gases, and by quantifying how rapidly sea level may adjust to climate change.

LINKAGE GRANTS

The Australian National University

LP120200626
Pillans, Prof Bradley J; Hiscock, Prof Peter ; Dosseto, Dr Anthony ; Papp, Dr Eva ; McPhail, A/Prof D C
Landscape evolution, environmental change and human occupation history of Lake George - an outstanding natural archive
Total $370,000.00, PHYSICAL GEOGRAPHY AND ENVIRONMENTAL GEOSCIENCE
Partner Organisation(s): Grantham Park Pty Ltd, Grantham Holdings Pty Ltd, Tobiway Crushing Pty Ltd
This project will study the environmental and human history of Lake George, where sand and gravel are mined to supply the Canberra region's construction industry. The project will investigate past vegetation and climate changes, lake level fluctuations, groundwater flow, sediment deposition, archaeology and sustainable resource management outcomes.

The University of New South Wales

LP120200724
Fogwill, Dr Christopher J; Turney, Prof Chris S; Meissner, Dr Katrin J
Integrating past ice sheet dynamics with palaeoclimate in the Weddell Sea sector to evaluate current and future change in Antarctica
Total $270,000.00, PHYSICAL GEOGRAPHY AND ENVIRONMENTAL GEOSCIENCE
Partner Organisation(s): Antarctic Logistics & Expeditions LLC (ALE)
This project will extend historical records of change and understand the complex linkages between Antarctic climate and ice sheet dynamics, thereby assisting in: (i) identifying the mechanisms of past and future ice sheet stability, and (ii) communicating the research outputs to the general public, helping scientific understanding.

The University of Sydney

LP120200259
Clarke, Dr Anne F; Bashford, Prof Alison C
The archaeology and history of quarantine
Total $820,000.00, ARCHAEOLOGY
Partner Organisation(s): Mawland Quarantine Station Pty Ltd
This project investigates the stories of people, place and passage inscribed in the landscape at Sydney's Quarantine Station. Immigration connects people and places to the wider world, and this project investigates the international connections that bind the experience and history of quarantine and diverse immigration sites across the globe.

Griffith University

LP120200093
Croke, A/Prof Jacqueline C; Olley, Prof Jonathon M; Macklin, Prof Mark G; Pietsch, Dr Timothy J; Fryirs, Dr Kirstie A; Thompson, Dr Christopher J; Cohen, Dr Timothy J; Burton, Dr Joanne M; Smolders, Dr Kate E
The big flood: will it happen again?
Total $480,000.00, PHYSICAL GEOGRAPHY AND ENVIRONMENTAL GEOSCIENCE
Partner Organisation(s): Queensland Department of Environment and Resource Management, South East Queensland Water
If we could better predict the frequency of extreme flood events, would we be better prepared to safeguard human lives and settlements? This project provides a time-line of flood activity in the south east Queensland region extending back thousands of years using state-of-the-art dating techniques and seeks to identifiy those settlements most at risk.

LP120200144
Lambert, Prof David M; Millar, Dr Craig D; Willerslev, Prof Eske ; Curnoe, A/Prof Darren K; Tacon, Prof Paul S; Li, Dr Ruiqiang
The peopling of East Asia and Australasia
Total $554,879.00, OTHER ENVIRONMENTAL SCIENCES
Partner Organisation(s): University of Copenhagen, Novogene Bioinformatics Technology Co. Ltd
This project aims to recover DNA sequences from ancient human remains from Australia and Asia some dating back 45,000 years. The project will use this information to identify the geographic origin of these people and to determine their genetic histories.

QA

ALAN GORDON THORNE 1939-2012

Obituary by Jim Bowler, assisted by Maggie Brady

The Canberra death of Alan Thorne on May 21, 2012, marks the closing of his pioneering contribution to Australian archaeology in general, and to physical anthropology in particular. Alan's life has been witness to an explosion of ideas about human origins, to new understanding about the earliest Australians, and to the forging of new working relationships between science and traditional people. No shortage of controversies on one hand; no shortage of challenging ideas on the other.

In 1957, Alan had just become a cadet journalist with the Sydney Morning Herald, when the paper sent him off to Sydney University to take an Arts degree. He obtained a BA in 1963, majoring in zoology and anthropology, then completed an MA (Hons) in 1968; then finally left journalism to join Sydney's Department of Anatomy under Prof N.W.G. Macintosh ("Black Mac"). Alan became a tutor and demonstrator in neuro-anatomy, dental and comparative anatomy. Given Mac's years of dedication to the pursuit of early skeletal remains, including crania from Talgai, Mossgeil, Keilor and others, Alan's inheritance of the Macintosh mantle seemed a logical continuation. This came to fruition in the dramatic circumstances of the early Mungo and Kow Swamp discoveries.

Our first involvement together was something of a milestone for both of us. When the bones of Mungo I, that I had discovered six months earlier, were removed from Mungo in 1969 by archaeologists in John Mulvaney's suitcase, and were positively identified by John Callaby in Canberra as human, the dilemma then arose: "What to do with them?" (Plate 1).

The list of available physical anthropologists was quite short. In Sydney, "Black Mac", after many years of research into ancient human skeletal remains, would have given his back teeth for them. However in 1971, amongst the staff due to join Professor Jack Golson's ANU Department of Prehistory (in 1971) was Alan Thorne. As a recent graduate from Macintosh's department, Alan was part of a new breed in the rapidly expanding field of Australian archaeology. It proved an inspirational choice. He responded with instant enthusiasm.

Physical anthropology was facing two challenges: on one hand, a shortage of ancient materials; and on the other, hostility from Aboriginal Australians. Under the post-Darwinian aegis of misplaced human biology, the early part of the century had seen plunder of Aboriginal graves by unscrupulous collectors. In the wake of indecent scrambles for skeletal remains by universities and museums, Alan's task was fraught with minefields. It was not going to be a smooth road.

His analysis of the Mungo remains identified those of a young woman subjected to ritual cremation, arguably the world's earliest. That announcement came as something of a shock to an astonished archaeological world unaccustomed to hearing such news from antipodean Australia. Six months of painstaking reconstruction followed, involving a jigsaw puzzle of more than 300 burnt bone fragments. The resulting cranial profile of a fully modern young woman, (known today as *Mungo Lady*) became a new and iconic statement of the earliest Australians (Plate 2). Little different from us, she became both a source

Plate 1: Mungo pioneers, Alan Thorne, Harry Allen, Wilfred Shawcross, John Mulvaney, and Jim Bowler at Joulni, site of discovery of the earliest human remains. Photo taken at the Legacy of an Ice Age Conference, September 2006. (Photo: Bernie Joyce)

Plate 2: Profile of the fully modern human, Mungo 1 "Mungo Lady". The cranial reconstruction is the product of six months' work involving more than 300 fragments. This remarkable work stands in testimony to Alan's contribution to the Mungo story. (Photo: Alan Thorne)

of pride to Aboriginal people, and put an end to any remnants of dark race inferiority postulated in the social Darwinian aftermath.

Meanwhile, Alan had further discoveries in store. In the bowels of the Museum of Victoria, he had already tracked down a cranium from near Cohuna. This had a distinctive, rugged or robust morphology, and was significantly different from that of Mungo Lady. The "robust" Cohuna cranium led to the now celebrated story of the Kow Swamp people. Detailed excavations (1968-72), which resulted in the recovery of some 22 individuals, attracted wide attention, both nationally and internationally. The attraction of this discovery was emphasized by its exposure at the Orientalists Conference, Canberra, in 1970.

The rugged and apparently archaic morphology suggested to Alan a genetic link with ancient hominids (*Homo erectus)* in Java. Much discussion followed the hypothesis that the mark of Java was embedded in Australian ancestral remains. The issue became more complex when radiocarbon dates established the "more archaic" Kow swamp remains as significantly younger than the modern Mungo example. Alan's PhD thesis, awarded in 1976, was entitled*: Kow Swamp and Lake Mungo: Towards an Osteology of Early Man in Australia.*

This was a time (1970-80's) of great turmoil in Australia, at the centre of which lay the question: who owns history? Resolution (and relief?) was provided by legislation at both Commonwealth and State levels, which finally vested the ownership of Aboriginal heritage firmly in the hands of indigenous people. This dialogue has not always been smooth; the 1990 request that the Kow Swamp remains be returned from the Museum of Victoria and reburied prompted vigorous protest, and led to John Mulvaney resigning his Museum Fellowship.

Meanwhile, at Lake Mungo in 1989, the ownership of skeletal remains was effectively resolved at a meeting between scientists and traditional owners. That resolution resulted in the 1992 return, by Alan, of the Mungo Lady remains to the traditional owners. The handback ceremony at the site of the original discovery (Plate 3) - at Joulni on the Lake Mungo lunette - marks something of a milestone in development of a new collaborative compact between scientists and Traditional Owners. This agreement continues to the present day.

Throughout those periods, when excitement was interrupted by tension or management vicissitudes, Alan remained a pillar of strength. He was one of the few scientists in whom the Aboriginal people retained complete trust.

Never one to back down from controversy, two events emerged to cement Alan's place firmly on the list of international movers and shakers. Firstly, his

Plate 3: In 1992 Alan sealed the accord between scientists and traditional owners by handing back the Mungo I remains. Witnessed by some 400 onlookers, Alan here hands the precious relics to Barkindji Traditional Owner, Badger Bates, at the Joulni site of the original 1968 discovery. (Photo: from Alan's files)

early conviction that gene flow from archaic (*Homo erectus*) populations in Asia had been transmitted to the early Australians, nourished the hypothesis for the multi-regional origins of modern humans. His 1981 publication with Milford Wolpoff (American Journal of Physical Anthropology) brought him into direct contention with supporters of the Out-of-Africa theory. Secondly, Alan continued to work on the ochre-decorated skeletal remains of Mungo III, jointly recovered with myself in 1974 (Mungo Man, Plate 4). His 2001 publication with Greg Adcock, discussing the DNA extracted from those remains, created something of an international sensation, a mixture of amazement with a high degree of incredulity. Both issues remain today as hallmarks of Alan's willingness to go where no others did. Although the pendulum seems to have swung against the multi-regional theory, the evidence of cross-cultural gene flow is now secure. Alan never wavered. His hypothesis may still hold some water.

Amongst Alan's defining skills, his confidence with the media, and especially with TV, should encourage us all to communicate our science to the public. Following a visit by ANU Quaternarists to China in 1975 (Donald Walker, Jeanette Hope, Ian McDougall, Joe Jennings and myself), Alan began a long courtship with Asia in general, and with China in particular. It inspired his 1988 11-part film series, "Man on the Rim: The peopling of the Pacific", co-written with Bob Raymond for the ABC. This series was a massive effort, even by today's standards.

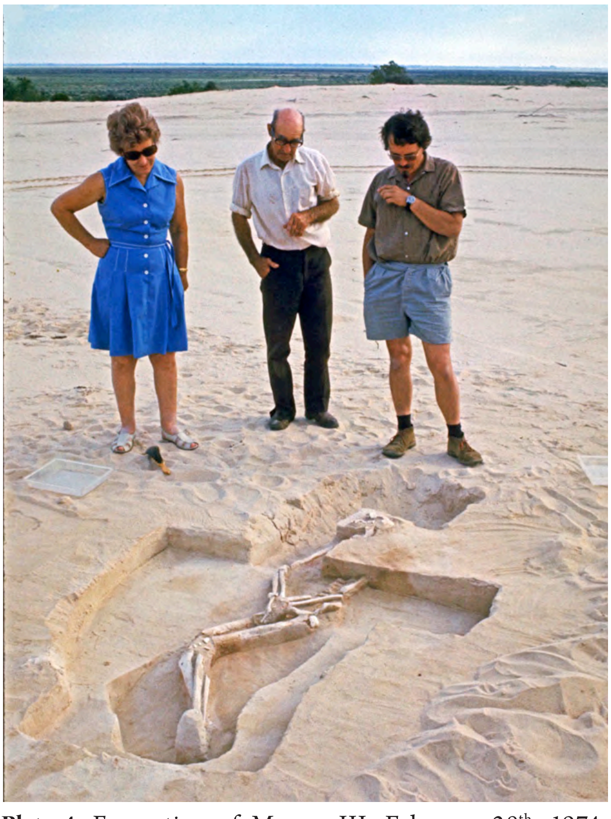


Plate 4: Excavation of Mungo III, February 28th, 1974. One of the special moments in the history of Australian archaeology. Alan in company with the late Venda and Albert Barnes, former owners of Mungo Station. They stand in silent testimony as Mungo Man's skeletal remains are recovered in January 1974. (Photo: Jim Bowler)

At his home in Canberra, Alan challenged suburban convention by harbouring a large colony of snakes beneath his house. His early interest in zoology was fostered through species interbreeding, including observations of the behaviour of his favoured Boa constrictors. Interbreeding and gene flow were contemplated as having possible parallels with human species.

At a personal level, our parallel paths were occasionally interrupted by different interpretations of the Mungo Man burial ages. We were both ever passionately searching for final credibility.

Since the Australia of the 1970s, where the number of physical anthropologists could all fit into a phone booth, the quantity of scientists under Alan's influence had more than doubled by the time of his death. Given both his research and media agendas, his influence in mentoring new generations of younger workers extended to many corners of the country. Alan's legacy continues with Steve Webb, Darren Curnoe, Peter Brown, Michael Green and Colin Pardoe.

While Alan's many important inputs include the multi-regional hypothesis of human origins and unsolved DNA mysteries, his lasting contribution to Australian archaeology will always be his work at Lake Mungo. His death will be acutely felt in the unfinished agendas of the Willandra Lakes World Heritage journey, precisely the point where his memory will have pride of place. His longtime desire to see an appropriate Keeping Place for the Mungo skeletal remains is now starting to see fruition. That iconic product of his meticulous reconstruction, the 41,000 year old cranial profile of Mungo Lady, is Alan's invaluable legacy and an historical monument for all Australians.

Above all, Alan's role in establishing the bond of trust between science and Aboriginal people stands as its own monument. That bridge stands in testimony to a new phase of working relationships between scientists and Traditional Owners.

Following the 1993 death of his first wife Judy in a car accident, Alan married Maggie Brady in 1999. Alan leaves two children, Rachel and Nicholas.

Physical anthropology in Australia and beyond is greatly diminished by his loss.

QA

Pictures of Time Beneath: Science, Heritage and the Uses of the Deep Past by Kirsty Douglas

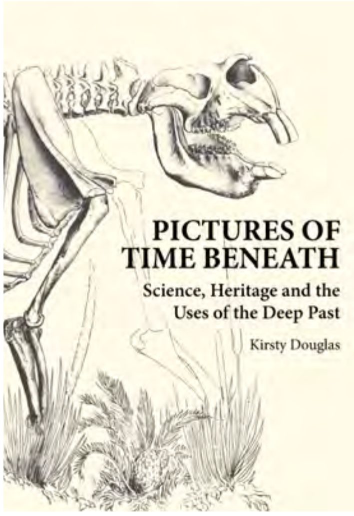
CSIRO Publishing, 2010, Paperback, 224 pages, ISBN: 9780643097049
AU$89.95, an eBook version is available from eBooks.com

Reviewed by John Magee

This book is essentially Kirsty Douglas' PhD thesis which was submitted to the ANU in 2004 after research in the History Program of the Research School of Social Sciences. The thesis was modified in 2009 for publication, but most of the science detail of the three main study sites was not updated, and some of those details have now been superseded by more recent discoveries. But this does not detract from the book, which is concerned not with the specifics of the science of each site but how they were discovered and researched and how the emergence of a deep-time perspective in Australia has impacted Australian Society.

The introduction is relatively long and somewhat convoluted. It does provide background information about the emergence of ideas about landscape and geology and how they might impact and influence society. It also provides a review of the concepts of deep-time from a philosophical perspective probably not usually considered by most geologists, which I found particularly interesting. While the introduction does provide setting and background for the interpretive framework of the book, it does not really provide the reader with a simple clear outline or summary of what will be said and why. That clear statement actually occurs in the last paragraph of the book, where the aims are rather eloquently and succinctly reviewed:

> "My aim has been to explore ideas about age in the landscape since the earliest public European acknowledgement of deep time in Australia, with the announcement of the Wellington Caves fossil discoveries in 1830. My major focus has been on the stories of discovery, interpretation, mobilisation, and celebration of that deep past by geologists, palaeontologists, archaeologists, museum workers and their publics in the 170 years since then. This is an account of the development of the significance of the deep past in Australia through the emergence of particular deep-time places into the realm of heritage, and thereby into regional, national and international frameworks of heritage recognition. People as well as ideas have passed through the places and narratives…"



The book examines three case study sites, each covering a different deep-time interval, involving different scientific disciplines and with differing heritage implications. The first case study is of Hallett Cove, on the St Vincent Gulf coast south of Adelaide when first studied, but now consumed by the urban sprawl. It is a site of purely geological interest, where evidence of the Permian glaciation (~280 Ma), which affected the south-polar Gondwana supercontinent, is preserved. Hallett Cove is surprisingly unknown to non-South Australians, even within the geological fraternity, but for most South Australians it has iconic status. Douglas' case study provides a wonderfully researched and presented history of the scientific discovery and the nature of the evidence which is interwoven with the wider story of the global discovery of former extended glaciations and the controversies raised by those discoveries. This is then followed by a detailed blow-by-blow account of the eventually successful battle to save Hallett Cove from urban development; a fight waged initially by a small group of geologists and later taken up widely by the public and the media. In another review of Douglas' book, Josephine Flood (in Australian Archaeology) criticises Douglas for not incorporating the archaeological findings of Norman Tindale at Hallett Cove into her narrative. In my opinion, that criticism is entirely unjustified, as the whole point of the case study is to present an example of very old deep time with emphasis on the geological heritage aspects. The archaeology is mentioned where relevant, but it is peripheral to Douglas' study. Flood's criticism reflects her own disciplinary bias, and perhaps her audience in AA, rather than the reality.

The second case study examines the Lake Callabonna Quaternary megafaunal fossil site, which is much closer in time to our present environment. However, with a probable age of 80-100 ka it almost certainly predates a human presence in Australia, and deals mainly with palaeontological aspects of deep time and scientific heritage. As for Hallett Cove, I found this case study to be a well researched and presented history of the scientific discovery and evidence, again skilfully interwoven with wider viewpoints. Douglas examines the history of Cainozoic vertebrate palaeontology in Australia, and the involvement of the main overseas exponents of the discipline in Europe, all occurring at a time when the major paradigms of geology as a science were being formulated and Darwin's theory of evolution was emerging. The story of petty jealousies, mismanagement and delays in both the discovery and excavation of the site are also detailed. The more straightforward story of protection of the Lake Callabonna fossil also exposes elements of the incompetence that seems to have characterised many aspects of Callabonna's site history.

The third case study examines the Willandra Lakes, the youngest of the three sites. The Willandra provides the point where humans enter the deep-time framework of the continent, and archaeology joins geology, and to a lesser extent palaeontology, as the relevant disciplines. Again the description encompasses multiple themes including the scientific discoveries and their history, the global context and the evolution of conservation measures resulting eventually in World Heritage listing in 1981. In particular, there is an excellent analysis of the whole issue of 'Who owns the Past' - or as in might be better expressed 'Who owns the Bones' - the conflict between scientific study and Aboriginal ownership of their own heritage which emerged in the Willandra, as elsewhere, in the late 1980s. This is a complex issue of competing, strongly held and incompatible viewpoints, which are all legitimate from differing perspectives. There are no simple answers but Douglas' review of the history and issues is highly informative.

Because of the remoteness and inaccessibility of the Callabonna site, few researchers are likely to have visited all three case-study sites. I count myself in that minority and have participated in field research both at Callabonna and particularly the Willandra Lakes where I also have had a long involvement in World Heritage management. But even for those without a strong personal connection to the case-study sites, I would highly recommend this book to any Quaternarist who has an interest in the history of our science and the discovery of sites and concepts and the impact those discoveries have had on society. It is an aspect of our science that most of us are probably only peripherally aware of. Many of Douglas' discussion points and inferences will probably be illuminating as well as often surprising. Even the Hallett Cove section which deals with a very much pre-Quaternary aged site has relevance, because the Quaternary is also a glacial period and Hallett Cove, when first discovered, was interpreted as a Pleistocene glacial site. The Hallett Cove case study contains ample discussion of the history of discovery of the causes of glaciation with obvious relevance to the Quaternary.

The narrative of all three case studies also includes much scientific detail and Douglas gets this mostly correct, despite being an historian rather than a scientist. This reflects the strong level of science in her undergraduate background, having done an honours project at Melbourne University on one of the Willandra lakes, supervised by Jim Bowler. Some of the minor scientific detail is not correct, such as a misinterpretation of 'parna' which is conflated with the concept of 'aeolian' to include sand dunes as well as clay-rich dust deposits. There are a number of other examples which I noticed, especially in the Willandra case study (probably reflecting my deeper knowledge of that site than the other two), but they are largely irrelevant and minor details which do not detract at all from the main purpose of the book. As a long-term member of the Willandra Lakes World Heritage area management committee, I was faintly amused to read that "World Heritage listing offers legislative protection" and "limited funding". The practical reality is that listing offers recognition and implies an obligation for protection but barely adequate funding for management that is drip-fed at best.

My only substantive criticism of the book, shared with Josephine Flood, is of the poor quality of many of the diagrams and photographs. There is no use of colour and many photos are dark, gloomy and some apparently in poor focus. Some of the line diagrams such as those demonstrating lunette morphology and sedimentary processes are so bad they look almost grubby. This does not reflect well on CSIRO Publishing and, for a modestly sized paperback book which is relatively expensive, the reader has the right to expect much better quality.

Finally, in strongly recommending this book, I feel that I should warn prospective readers that the writing style is complex and full of unusual and sometimes obscure terminology. As an example, the vegetation of the Willandra is described as 'salsolaceous'. It took me some concentrated Googling before I came to terms with that one. The book is therefore not a quick and simple read but requires real concentration and effort. I found that effort rewarding, Josephine Flood clearly less so. If the reader has handy access to a dictionary and possibly to Google, they will not only have an interesting and educational foray into the deep time of Australia, but will also learn a few new words in the process; surely a good outcome!

QA

Thesis Abstracts

Fixed intertidal biological indicators and Holocene sea-level on the Great Barrier Reef coast

Shelley Wright (PhD)
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Mid-to-late-Holocene sea-level behaviour for the Great Barrier Reef coast has been contentious for nearly a century. While evidence of emergence in some areas of this region is extensive, debate continues as to its origin. This study located and examined relic formations of intertidal assemblages preserved in growth position on the rocky headlands and islands of the Great Barrier Reef coast. The first evidence of emergence from new locations along 1200 km of coast and offshore islands from Lizard Island (Lat. 14.45°S) to Great Keppel Island (Lat. 23.35°S) is presented. Time-elevation data from these locations supports a model of a 1.5 – 1.8 m higher than present mid-Holocene sea-level with a sharp fall between 3800 and 3600 cal. BP to approximately 1.2 m above present. A further rapid fluctuation may have occurred between 3000 and 2700 cal. BP. Sea-level then remained between 1.0 and 1.4 m until after 900 cal. BP when it began to fall to present.

The disappearance or invasion of species recorded within these assemblages can provide further clues to past environments. Some species of barnacles have specific environmental requirements and their presence within a relic assemblage may provide evidence of past sea-surface and/or air temperature, salinity, or tidal range. In particular a species at the northern or southern limit of its range may be a sensitive indicator of change. Changes in species dominance appear in the sub-fossil record just prior to 3800 cal. BP and again after 2900 cal. BP, suggesting changing environmental conditions. In particular a cooling just prior to 3800 cal. BP is suggested.

Surveying the current tropical rocky intertidal zone to identify densities and living requirements of the key marker species allows a more accurate interpretation of past environmental conditions. This study carried out semi-quantitative surveys in order to refine the fixed intertidal biological indicator methodology and in doing so established a reference list of tropical barnacle species relevant to sea-level study. The northern boundary of the temperate barnacle *Tetraclitella purpurascens* has been extended and species such as *T. divisa* and *Tetraclita coerulescens* recorded at new locations.

This study has contributed to the understanding of mid-to-late Holocene sea-level behaviour for this region. It has also added to the knowledge of current tropical rocky intertidal zonation.

Environment, landscape and stone technology at Lake Mungo, southwest New South Wales, Australia

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This study investigates one methodology for extracting useful information about variability and change in human behaviour from low density surface archaeological remains scattered across a large, complex and eroding Pleistocene landform. Lake Mungo, part of the Willandra Lakes Region World Heritage Area in south-west New South Wales, provides the setting for this case study. Stone artefacts in eroding surface contexts form a large proportion of the Willandra Lakes archaeological record, yet have contributed little to our understanding of past behaviour in this area. This study is among the first to apply the combination of a landscape approach to data collection, GIS modelling and theories of technological organisation to the interpretation of this unique and important record.

Two study areas at Lake Mungo contain sediments representing a change from consistently high lakes to fluctuating and drying lakes, between approximately 25 ka and 15 ka. Detailed mapping and analysis of geomorphology and artefact distribution indicate that,

although geomorphic processes have redistributed some of the surface material, there are areas that have retained some stratigraphic integrity. This study defines three assemblages of chipped stone artefacts that can be reliably associated with particular stratigraphic layers and thus with particular environments and landscapes. These assemblages are interpreted using the framework of technological organisation. Differential use of raw materials from different sources, the intensity of stone use, and the relative frequency of particular artefact types are investigated. This enables inferences about raw material conservation, strategies of provisioning and the movement of people around the landscape. Differences between the assemblages do not correspond in a straightforward way to differences in palaeolandscape or palaeoenvironmental context, and this provides a springboard for discussions about the structure of the archaeological record and the way in which we derive information from assemblages that have accumulated over different time spans.

QA

Recent publications

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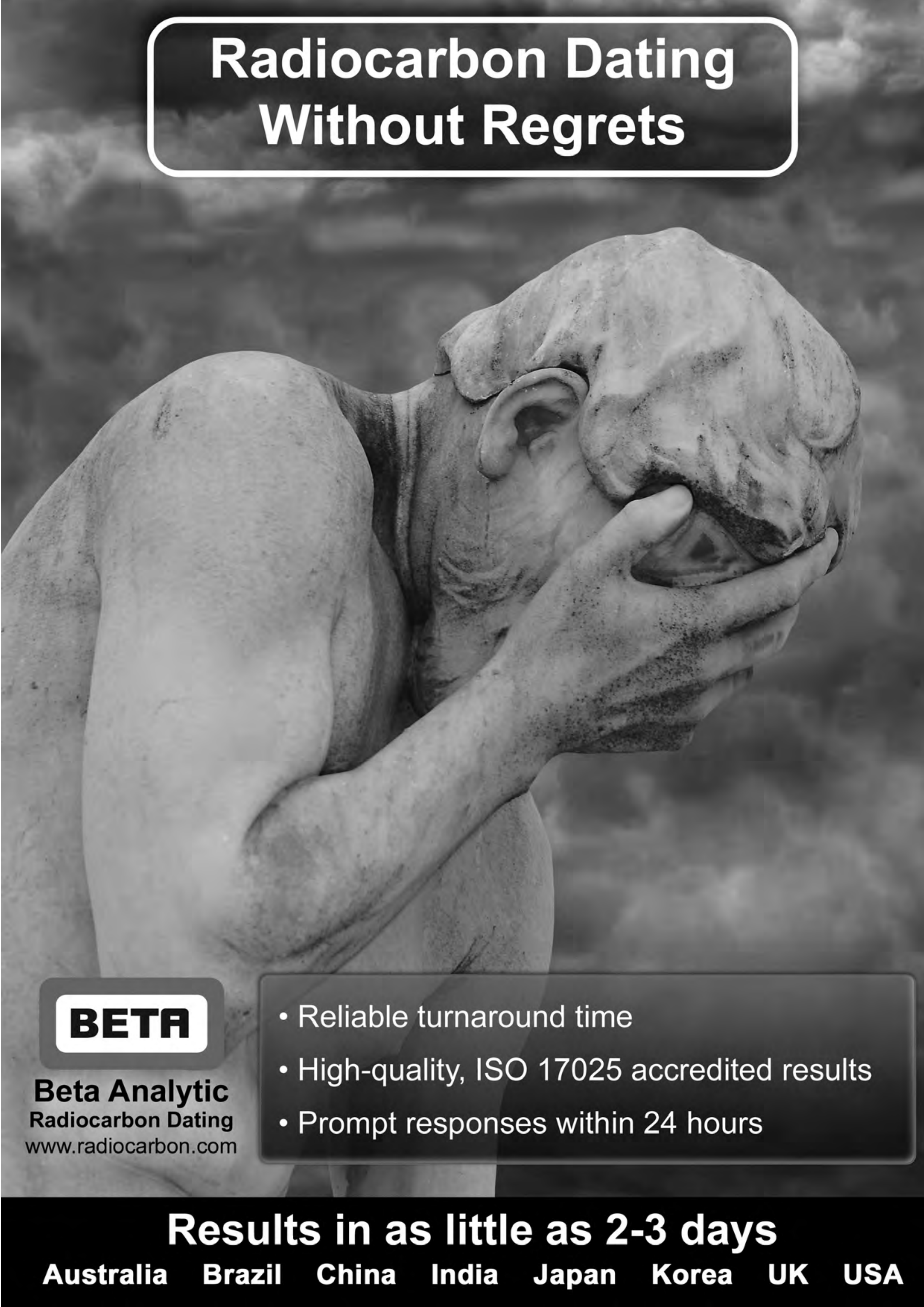
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The annual subscription is AUD50, or AUD35 for students, unemployed or re- tired persons. To apply for membership, please contact the Treasurer (address below). Members joining after September gain membership for the following year. Existing members will be sent a reminder in December.

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