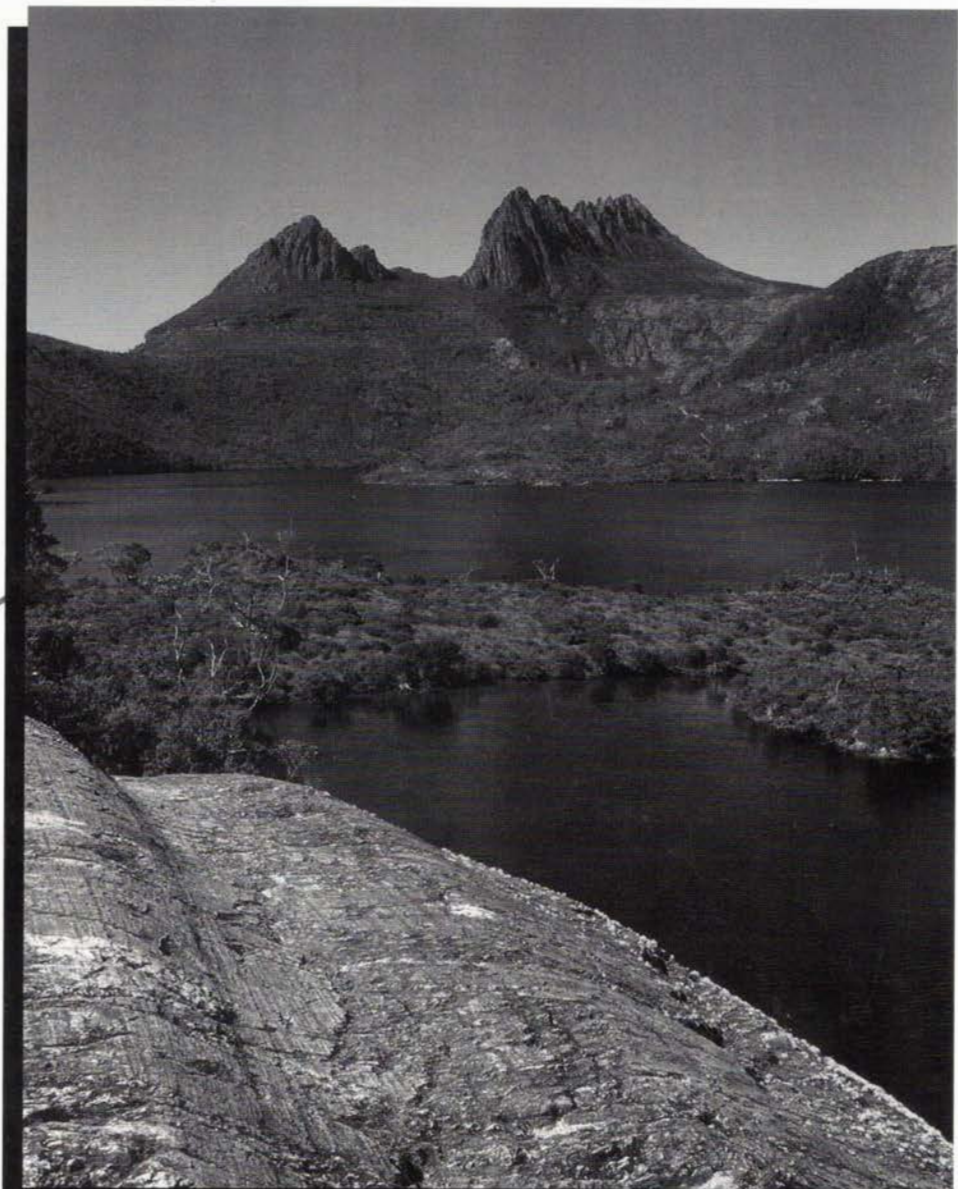




QUATERNARY AUSTRALASIA



"Short periods of mild activity interspersed
with long periods leaning on the shovel..."



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OHS violation of the month



Greg Jordan leading by example on his botanical walk at Cradle Mountain. (Photo: H. Heijnis)

Cover photo

Glacial pits and striations on 'Suicide Rock' beside Dove Lake and Cradle Mountain. (Photo: B. Alloway)

This issue follows the AQUA 2004 bi-annual conference held in early December, 2004, at Cradle Mountain, in the highlands of Tasmania. Day after sunny, gorgeous day under the Alpine Ash, dazzling Waratahs dripping nectar, bandicoots in the bushes, wombats wandering on the roads. What more could you ask for? While the southeastern mainland rumbled and rained under a persistent low that would be followed, in early 2005, by several spectacular rain events, we got sunburns under more than one week of consistent, ultraviolet-rich sunshine that represented something like one quarter of Cradle Mountain's average annual allotment.

In this issue, you will find reports of pre- and post-conference field trips, abstracts of the two prize-winning student presentations, and an abstract of the plenary talk given by Eric Colhoun, detailing the history of study of Tasmanian glaciation. In addition, there are two reports of conferences, of the Australian Archaeological Association and the International Geographical Union; and of the paired INTIMATE meetings in Australia and New Zealand that took place in late 2004.

I received a healthy response to my encouragement to students and their supervisors to supply Honours and post-graduate theses abstracts for publication: we have eight of them in this issue. This is important, not only because the results of post-grad and especially Honours studies frequently appear in print only belatedly, if ever, but because such abstracts may be capable of providing a steady stream of ready made, topical, interesting copy for this magazine, material which, I emphasise, otherwise proves difficult to extract from the Australasian Quaternary community. So please, students, keep QA in mind as an efficient and simple way to share the results of your thesis with the regional Quaternary community,

and supervisors, please remind your students, who may not (yet) be AQUA members, to submit their Quaternary-based thesis abstracts. While on the subject of contributions to this magazine, I point out that commencing with this issue QA will be available, in pdf form, on the AQUA website (<http://www.aqua.org.au>), which should receive increasing attention in the run up to the XVII INQUA Congress in 2007, in Cairns. Also, copies of the next several issues of QA will be available at the 2007 Congress, as back issues for purchase and to tempt new members. Thus QA will be read by a larger audience than at any time previously. Isn't that a compelling reason to contribute something to the next issue?

The AQUA AGM resulted in a few changes to the executive. Simon Haberle departed from the presidency, while Henk Heijnis took up that mantle. Stuart Pearson was elected secretary, while AQUA entered a new age of global diplomacy with the appointment of a European liaison committee made up of Justine Kemp, Helen McGregor, and Jan-Berend Stuut. After discussion, members voted to increase AQUA membership fees, to \$35 (ordinary members) and \$25 (students, unemployed, pensioners), largely reflecting increased costs of producing QA. The next AQUA AGM will be held in late 2005, in the Sydney region, while there was discussion of holding the next bi-annual conference in late 2006 or early 2007, near Mt Egmont, New Zealand.

This issue's stratigraphy quiz: Find the cultural reference to Derek Ager's most (er...perhaps only) famous phrase.

Kale Sniderman

Editor

DEPARTING PRESIDENT'S PEN

As fate (and my poor time management) would have it, I'm writing this final President's Pen during a ("Long Island Ice Tea") break in the proceedings at a conference on "Tropical-Extratropical Climate Teleconnections, A Long-Term Perspective" in Hawaii. The aim of the conference is to bring together palaeo-climatologists and climate modellers to try to talk a similar language and develop closer collaborations across these all too often disparate groups. While most of the participants are from the US, there seems to be a hunger for input from the Southern Hemisphere and a recognition that the models and the palaeodata remain thin on the ground from half the globe...a theme familiar to us, but surely something that promises new opportunities for the Quaternary community in Australia and New Zealand. How we tackle this over the next decade will be crucial to the long-term survival of the discipline in the region.

One opportunity to showcase the regional efforts in Quaternary research is rapidly approaching in 2007 with the INQUA meeting in Cairns. The efforts from AQUA members over the next two and a half years will be critical to the success of this meeting... one measure of which is the increased international collaborations that develop because of the casual meetings at this event...which not only can bring

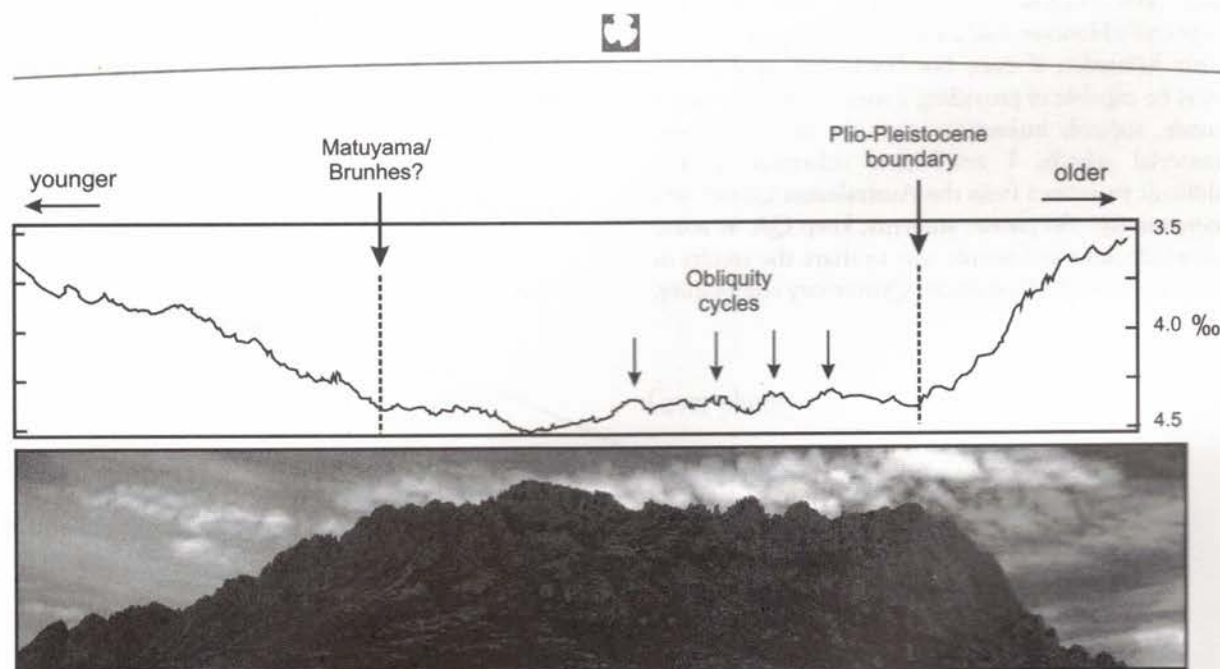
intellectual exchange but potentially alternative financial support outside the sources of ARC and Marsden grants. I encourage everyone to support the efforts of Henk as the new President of AQUA, and of the INQUA 2007 organising committee members in making this a success...

Cheers,

Simon Haberle



AQUA ex-president and treasurer atop Tasmania.
(Photo: J. Stevenson)



Cradle Mountain: a new proxy for late Cenozoic global ice volume!? Weren't just sitting around doing nothing at the foot of Cradle Mt... Sense of isotopic values reversed for comparison with benthic oxygen isotope records. Photo and concept: S. Pearson Execution: K. Sniderman

Redefining the Quaternary: ICS-INQUA joint task force on the Quaternary

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For over a century, the status and stratigraphic position of the Quaternary have been debated. Authoritative papers on the history of Quaternary, and its recommended stratigraphic definition and status include Berggren (1998), Lourens et al. (2004), Ogg (2004), and Pillans (2004). The INQUA Executive, through consultation with the Quaternary community in 2004, has found widespread support for defining the Quaternary as a chronostratigraphic unit with a base at 2.6 Ma. As a consequence, ICS and INQUA consider it timely to decide on the stratigraphic meaning of the Quaternary, so that it can be unequivocally placed in the standard global time scale. John Clague, President of INQUA, Felix Gradstein, Chair of ICS, assisted by outgoing IUGS President Ed de Mulder, have agreed that a task force be struck that will make a recommendation to ICS on the definition of the Quaternary in 2005.

The task force on the Quaternary will comprise members of INQUA and ICS, and will be charged with the single task of defining the Quaternary in a stratigraphic sense. It will formulate a single proposal that will be discussed at the Second ICS Workshop on the Future of Stratigraphy in September 2005 in Leuven, Belgium. This workshop will be attended by the chairs of all Subcommissions of ICS, and the President of the INQUA Commission on Stratigraphy and Geochronology. If the task force recommends definition in a formal chronostratigraphic sense, its proposal will go through the standard ICS consultation, voting, and ratification procedures.

The task force will consist of eight members and will receive advice and input from its wider constituency. The members of the task force are:

Chair: James Gehling, Australia
Vice-Chair: Brad Pillans, Australia
Secretary: James Ogg, USA

Two members of INQUA Commission on Stratigraphy and Geochronology, appointed by the executive of INQUA

Three members of ICS Subcommission on Quaternary Stratigraphy, appointed by the executive of ICS

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Professor Patrick De Deckker, ANU (shown above at Lake Gnotuk during a coring trip in November 2003) has been awarded the Australian Society for Limnology medal for 2004 in recognition of his contributions to palaeolimnology and the study of salt lakes. For more information, visit http://www.asl.au/asl_medal_recipients.htm Patrick

Eucs, Button-Grass Plains and a not-so-crazy Irishman: Glacial Cycles & Vegetation Change in northern & western Tasmania

Led by Ian Thomas and Eric Colhoun 3-5 December 2004

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Isn't Tasmania described by the mainland Australians as the "New Zealand of Australia"? As a citizen of the real New Zealand I was quite intrigued by Tasmania's hard-done reputation...Hmm...why was it that so many of my friends and countrymen were going there to live (of course, not at the expense of the Australian taxpayer) and what was it about the place that makes Tasmania stand out from the rest of Australia? Were the mainlanders secretly jealous of the small, close-knit communities? Were the rumours of greater numbers of fingers and toes true? Why were the Tasmanians reportedly such good banjo players, and could Franklin's fatal north-west passage expedition be somehow attributed to his prior governorship of Tasmania? I threw caution to the wind; I signed up for Ian Thomas's and Eric Colhoun's field-trip. For the first time I was about to get a close-up and personal glimpse of Tasmania, I was about to discover the truth about the place.

The excursion all started in Devonport, a small picturesque town on the northern Tasmanian coast with ferry linkages to the mainland. I distinctly remember making the journey to Devonport from Toronto, Canada via Auckland then onto Melbourne with two pieces of luggage. I remember checking in the same luggage at Melbourne for the short jaunt across the ditch to Devonport. However, only one bag arrived. The other bag, with all my camping gear, mysteriously found its way to Perth and arrived at Cradle Mountain the day after the field-trip had ended. Not a good start. Devonport was nice: yes, this could easily pass as a quiet South Island town. Similar designs in residential housing (Victorian through to asbestos-lined Hardy constructions) dairies, fish'n'chip shops, colonial shop facades, banks and franchise stores all owned by overseas interests

(just like in New Zealand). Jandals, walk shorts and hotted-up Holdens. This was very much like New Zealand and it felt familiar and somehow comforting.



Figure 1: A debonair-looking Ian Thomas (University of Melbourne) at Linda Pass with till as a convenient backdrop and seat. (Photo: B.V. Alloway)

Our Friday morning rendezvous and pickup was at the Devonport ferry terminal. Also there were Janece and Laurie McDonald (University of Newcastle) and Dave Roberts (Council for Geoscience, RSA) waiting for pickup. Initially, Dave Roberts (who obviously was jet-lagged) thought I was Ian Thomas; after all, it's an easy mistake to make since Ian and I are both handsome, well-conditioned, middle-aged dudes. The initial confusion was sorted by some introductions and the realisation that I, like Dave, had no transport or any knowledge of where we were about to go or what we were about to experience. Ian Thomas (Figure 1), a well-known palaeoecologist from the University of Melbourne and one of the trip leaders, duly arrived in a van accompanied by Anna Chappell (Victoria University of Wellington). Warm introductions were made, the weather was perfect and we were all set to go.

We met up with the other members of the group in Deloraine, where a picture perfect classic two-storey country pub exists complete with veranda and decorative filigree. This may be ho-hum to my Australian colleagues, but to me this was an Aussie cultural icon to admire. At Deloraine we were introduced to Eric Colhoun, the other leader of the trip and renown Tassie glacial geomorphologist and jack of Quaternary trades (Figure 2). Once Eric detected that I was the only kiwi in the group, his immediate question to me was if I knew the significance of Munster Province in Ireland. Hmm...provocative question as an introduction: I was puzzled. Eric then had my full attention. The question would be asked repeatedly over the duration of the field-trip as a sort of brain teaser/slow form of torture and was answered with the same blank look and shrug of the shoulders. Damn! Where was Google when you needed it! Eventually, it would be teased out over the weekend that Eric was an avid rugby player and ex-representative player, but I was no closer to solving the question.

Our first day was spent driving up to the Central Plateau to inspect alpine and sub-alpine plant communities and limits of the Last Glacial ice sheet. Our first stop was at Pine Lake where Cecilia Elwood (Monash University) gave a very interesting account of her vegetation record research at the lake. Unbeknown to us at the time, Cecilia was feeling ill from the effects of something too savoury she had consumed earlier in the day. She performed admirably but her health got progressively worse during the course of the day, to everyone's concern.

On the way to Lake St. Clair Ian outlined *Eucalyptus* pollen transport modes across Liawenee Moor adjacent to Great Lake, and we were able to observe the razor sharp boundary between the grass- and herb-dominated moor and the open woodlands on the Jurassic dolerite. At Cynthia Bay at the southern end of the very scenic Lake St. Claire, Eric introduced the impressively detailed glacial geomorphology of Kevin Kiernan as well as the surface exposure dating of Tim Barrows *et al.* After a night of wining and dining at the Derwent Hotel (not to mention a comfortable bed, remembering that I had no camping gear) we continued down the Lyall Highway and were introduced to the Quaternary deposits of the King Valley: the button-grass plains are convenient shelter to a great variety of snake species that you didn't know existed until you actually stood on one. Here, many of the glacio-fluvial deposits mapped by Sean Fitzsimons and Eric Colhoun are intensely chemically weathered. Consequently, the fragmentary deposits are distinguished on the basis of a combination of landscape associations, weathering rinds, till fabric analysis, amino acid dating and

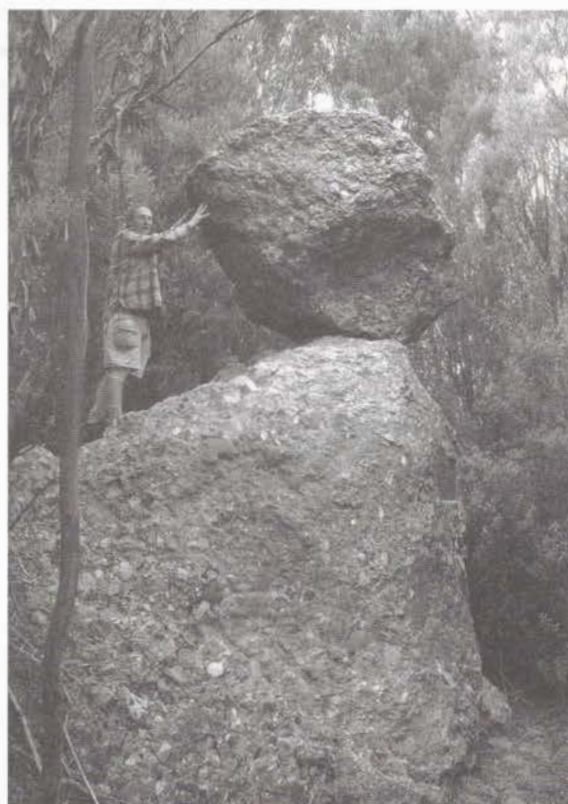


Figure 2: Three Glacial erratics on the Zeehan Highway. The erratic standing to the left is Professor Eric Colhoun, University of Newcastle. (Photo: B.V. Alloway)

palaeomagnetism. We also learned that the value of ^{14}C dating in the development of the King Valley stratigraphy was limited because the ages of most glacial sediments in the area were well beyond the limits of the technique.

At the end of the day we arrived in the mining town of Queenstown after looking at the glacier limits in the Linda Valley and the gaping open cast porphyry copper mine in the vicinity of Gormanston (Figure 3). The only thing Queenstown, in Tassie, has in common with its New Zealand counterpart was apparently the name. No crystal-clear Lake Wakatipu fringe or Remarkables backdrop to greet us, just derelict and run-down buildings, stunted and acid-rain affected vegetation, plenty of bare ground and contaminated bright orange-coloured streams. Such a huge contrast to what we had seen of Tasmania so far. Apparently, in response to natural vegetation regeneration of the acid-rain affected landscape surrounding the town, the local council once proposed to restore Queenstown's stark former mining heritage by embarking on a program of revegetation! What environmentally-friendly appeal this town obviously lacked was generously made up by the colourful assemblage of patrons encountered later that evening at the Empire Pub. The locals were friendly enough, but by the time a strong contingent

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of police closed the bar at 2 am many of the patrons weren't any wiser as to what we were on about nor couldn't really care less.

The next (initially blurry) day was spent on the Zeehan-Murchison Highway heading towards Cradle Mountain and looking at the spectacular glacial features of the Tyndal Range and discussing the high resolution sediment core retrieved from Lake Selina. A highlight was seeing the stacked erratics (Figure 2) and seeing the truly magnificent Hamilton Moraine, which judging from its pristine form seemed to have been deposited the very night before – the same time when we were intent on killing brain cells with the locals in Queenstown. It was surprising to learn that exposure dating indicated a mid-Pleistocene age of the moraines, quite remarkable! We continued to inch our way to Cradle Mountain and stopped by the Boco Plains where Paul Augustinus as part of his thesis work used any means possible (weathering rinds, magnetisation and U/Th dating) to characterise the mid-Pleistocene Boco and Bulgobac Glaciations. Michael Fletcher (University of Melbourne) shed light on what the vegetation of the region was like prior to Aboriginal arrival, further supporting the notion that people maintained a presence in the interior of western Tasmania and that the present fire-promoted Buttongrass moorland is an artefact of continued occupancy throughout the Holocene.

At the end of the three day excursion what impressed me was that we were shown numerous examples of quality field research in a chronologically challenging but stunningly beautiful Tasmanian environment. Eric, together with his array of former students (i.e. Kevin Kiernan, Sean Fitzsimons, Paul Augustinus, Andy Hammond) and research collaborators, have worked tirelessly to understand the Quaternary history of Tasmania using whatever resources and techniques available to them. Without robust understanding of relative stratigraphy and geomorphic relationships the recent and significant advances made by surface exposure dating would be rendered quite meaningless. There now seems to be a shift away from gross hemispheric-wide glacial correlations (Tasmania-NZ-South America) towards recognition of regionally influenced glacial events. Also, there is a growing appreciation that glacial events aren't necessarily restricted to full-glacial climatic events (i.e. OIS 2, 4, 6) but advances could conceivably occur during OIS stage 3 (as recent surface exposure dating seems to suggest) and perhaps even during the cooler intervals of OIS 5 (substages 5b & 5d). Much still remains to be done, but whatever is done

in the future to unravel Tasmania's glacial history, it will be built on a solid foundation of field research conducted by a team of dedicated individuals led by and large by Eric Colhoun. So thanks Ian and Eric – a truly fine excursion and experience. A note of thanks should also go to the other contributors, in particular Cecilia Elwood, Andrew Hammond, Michael Fletcher and Simon Conner, who generously shared their knowledge and/or helped out with the smooth running of the trip.

Finally, I never did manage to see any Tasmanian play the banjo, so I don't really know what all the fuss is about. I guess at the end of the day it's all about island envy. You can't really expect us *bone fide* New Zealanders to see the so-called 'New Zealanders of Australia' in a peculiar light – now can you?!

Oh, and by the way, the answer to Eric's brain tease was that Munster defeated the All Blacks in 1978 (12-0) – something that would now be indelibly etched in my mind forever! Hey, Eric...can you bend it !?



Figure 3: Excursion participants at the porphyry copper mine lookout at Gormanston. Back (left to right) Janelle Stevenson, Simon Haberle, Christine Kenyon, Cecilia Elwood, Merna and Bill McKenzie, Michael Fletcher, Angus Tye, Janece and Laurie McDonald and Andrew Hammond; Front (left to right) Dave Roberts, Eric Colhoun, Ian Thomas, Simon Connor and Anna Chappell. (Photo: B.V. Alloway)

Cosmos and culture – a field trip of cosmogenic dating highlights from the highlands of Tasmania

Led by Tim Barrows, 2-5 December 2004

Peter Almond

Lincoln University
Canterbury, New Zealand

In the Greek tradition, Cosmos referred to the order of the Universe, the antithesis of Chaos. So it was that Timmy "Stardust" Barrows brought order with cosmos to the chaos of Tasmanian glacial chronology. Like any young up-and-coming Quaternary cosmologist he had to break some rocks along the way, and we were privileged to hear his stories and visit some of the important dated glacial landforms of Tasmania. The intellectual experience was augmented by the aesthetic experience of the stunning Tasmanian highlands and its wildlife, and by the cultural interaction with the Tasmanians and between the Kiwis and Australians making up the group. They were: Kerry Tomkins, Duanne White and Paul Hesse from Macquarie University, Daniel Wilkins and Martin Worthy from ANU, and Matthew Hughes, Fiona Shanahan and Peter Almond from Lincoln University.

Ben Lomond, a short drive from Launceston where we congregated, provided an unfamiliar alpine experience for the Kiwis despite the similar vegetation. Here the mountains don't crumble beneath your feet or fall on your head, and in the perfect weather that lasted the whole trip, they seemed an almost hospitable place. The block fields formed from tumbled and shattered giant dolerite columns at the foot of vertical escarpments were so stable that only periglacial processes could encourage them to move. Rock-hopping across the Carr Villa block slope we traversed rock glacier ridges ranging in age from 22 to 500 ka. These are truly 'Aussie-roadcrew' landscapes – short periods of mild activity interspersed with long periods leaning on the shovel.

The drive down the mountain put on the first of the Tasmanian wildlife shows. Wallabies, pademelons and echidnas showed themselves. In fact echidnas changed status from endangered, to threatened, to common-as-tingo dirt (mate) by the time we reached Campbell Town.

At Mt Field National Park the poorer of us not staying in cabins got to sample the Aussie camping culture: a beautiful stream for bathing beside the camp, Daniel and Martin with cold tinnies and hot tea, and a free

BBQ with possums and pademelons for company. The following day brought the highlight of the trip for me. The relative youth and fitness of the group allowed Tim to be adventurous and he guided us on a six hour walk along Tarn Shelf and around the back of the Rodway Range. Here the moraines of Tasmania took on a familiar look to the New Zealanders. Lake Seal lay impounded behind large lateral and terminal 'LGM' moraines. I use inverted commas not because I doubt the dating but because the "maximum" part of Last Glacial Maximum needs qualification. Down valley from the moraines impounding Lake Seal two glacially deposited boulders returned MIS 3 cosmogenic ages. Likewise, in New Zealand, MIS 4 glaciers appear to have been at least as large as those of the 'LGM'. I don't support abandoning the term because it's used with sufficient imprecision to be really popular. Perhaps we can just note whether we are referring to the Last-glacial maximum or the Last glacial-maximum. The climb up the Rodway Range back to camp was where Daniel, Martin and Duanne showed their mountain men mettle and ensured a cracking pace. Paul was to act as their foil.

Dinner was awaited eagerly that night after the long walk. We planned to visit the local pub across the river from our camp, only to find that dinner was off. The publican had a "not negotiable" attitude even to the charms of Fiona and we set off to New Norfolk for relief. Along the way we passed a young fellow, perhaps 13 years old, limping along the road trying to hitch a ride. We were 200m past him when Tim was convinced to "give the poor little bugger a ride". Signifying his unease, the boy crossed himself as he approached the van and he became visibly agitated when the van erupted into laughter as he got in. He took this as an ominous sign not realising that everyone was laughing at Fiona, who had taken the opportunity to step out and relieve her bladder and was at that time mooning one of the local commuters. The boy eventually calmed down and he confided in us that he had had an argument with his Dad and he was heading off to his Mum's place about 100 km away. When we dropped him off at New Norfolk he stepped out of the van, thanked us, pulled his kitchen knife out of his jeans and walked off. Things could

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have gone worse. After the pub roast, the game of Keno and watching the boys in the Holden drive past the pub many times, we headed back tired to Mt Field.

Tim had promised the Kiwis we would see at least one snake on the trip. The promise so far unfulfilled, we stopped by the beautiful vipers nest of Lake St Clair: no snakes but a stunning view of the lake under blue skies and our first exposure to Tasmanian outwash plains.

Queenstown, Tasmania is not like Queenstown, New Zealand. The Queen, Victoria presumably, would have been flattered by one of them. Queenstown, Tasmania is a landscape so scarred by mining that this attribute has become the tourist attraction. The colour of the local river is justification enough to go there, although getting dunked at the end of a bungy is probably not going to happen.

Cosmos again proved their worth at Lake Margaret. A walk up the service road for the penstock supplying the hydroelectric power station was great pickings for the rock hound. The service road led on to a tramway running along the penstock from which good views of the Hamilton moraines could be had. These moraines are the type section for the putative LG-M Margaret glaciation. Cosmos show the moraines to be of MIS 8 or 10 age. Did no-one look at the soils, I ask?

So, a big thanks to Tim Barrows for leading a well organised yet relaxed trip through some beautiful parts of Tasmania. The trip had the right balance of mental and physical stimulation and passed the fun test with flying colours. Thanks also to Kerry for your heartland Australia stories, Duanne, Daniel and Martin for being well equipped and for setting the pace, to Matthew and Fiona for deflecting kiwi jokes, and to Paul Hesse for your erudite conversation – I was ok after I realised a 'diphthong' was not your latest swimming costume.



Gondwanan co-operation: Brent Alloway (NZ), Bill McKenzie (Australia) and Dave Roberts (South Africa) attempt to fix Merna McKenzie's shoes at Lake Selina. (Photo: C. Elwood)

AQUA at Suicide Rock – A report by the AQUA International Liaison Officers*

Helen McGregor and Justine Kemp

After a stimulating week of talks and posters, Tim Barrows (ANU) led us on a tour of former nested cirques and valley glaciers around Cradle Mountain. After examining erratics stranded on the glacially over-deepened valley floor that now contains Dove Lake, Tim led us to 'Suicide Rock' (were things to end before they'd begun?), where we discussed the new glacial chronology based on cosmogenic dating of glacially eroded bedrock. David Fink (ANSTO) explained why one erratic is not as good as another, and Tim elaborated on the finer points of sampling rock from popular viewing spots in National Parks. Pitting and striations on the bedrock vouched for the 200 m of glacial ice that stood in Cradle Valley during the last glacial maximum, the most recent ice advance. Here, the ice extended only some five km down-valley although longer valley glaciers existed elsewhere in northwest Tasmania. As Tim and David would explain, the deglaciation did not coincide everywhere, with glaciers in eastern Tasmanian showing the first signs of retreat. The place we stood contained one of the last glaciers to disappear, rapidly, after 17,000 years ago.

From 'Suicide Rock' we proceeded up the steep arête that separates Dove Lake from the small cirque Lake Hanson. Spectacular views emerged of the plateau of Jurassic dolerite that caps older Triassic and Permian sedimentary rocks. The plateau is extensive to the south and east and is deeply incised by streams draining away from Cradle Mountain. To the northeast, a small patch of brighter green suggested civilisation. We continued towards the base of Cradle's headwall, met, and lunched with, the second group looking at alpine ecology.

Invigorated by the cheese and alfalfa sandwiches, and with the promise of even more splendid views on a rare, cloud-free day, some of us set out to conquer the craggy 1545 m peak of Cradle Mountain itself. This did not prove straightforward, requiring sturdy shoes for scrambling over the bouldery mountain flanks. But the top was magnificent; providing a 360-degree view, clear blue skies and even some snow to refill our water bottles. After some time sun-basking and locating the lower peaks around us, we headed back down slope, and slowly (stiffly?) meandered back along the eastern ridge. A truly rewarding day.



The craggy peak of Cradle Mountain with the intrepid AQUA participants. (Photo: J-B. Stuut)

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The Study of Tasmanian Glaciations 1973-2004

Summary of Plenary Talk at Cradle Mountain

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Tasmania, like New Zealand and Chile-Argentina, preserves a record of terrestrial glaciation important for the Quaternary history of Southern Hemisphere mid-latitudes. After the first glacial deposits were found in 1859-60 by Charles Gould, limited observations were made until the Hobart lawyer Arndell Lewis proposed a 3-fold model of glaciation based on work carried out between 1920 and 1945. He visualised a last glaciation with small cirque and valley glaciers, a preceding larger glaciation with valley glaciers and an extensive early glaciation with ice sheets over much of western Tasmania. The first radiocarbon date was obtained in 1956 from Linda in deposits supposed to belong to the oldest glaciation. The assay of 26,480 \pm 800 yr BP (W323) caused many to think that most glacial deposits in Tasmania were no older than the last glaciation, and the *Glacial Map of Tasmania* (1965) was constructed largely on this premise.

By 1973 there was a need to test if the glacial history of Tasmania belonged mainly to one event or whether numerous glacial events had occurred. Attention was given first to the West Coast Range (WCR) where Lewis's 3-fold model had largely been determined. Field research by Eric Colhoun, Adrian Bowden, Kevin Kiernan, and others during the 1970s and early 1980s, when development of roads and dam exploration in the area provided much exposure, soon demonstrated that:

1. Last glaciation ice was of very limited extent in the WCR but more extensive in central Tasmania.
2. A radiocarbon assay from the base of outwash deposits at Dante Rivulet gave an age of 18,800 \pm 500 yr BP (ANU 2533) and closely dated the maximum extent of OIS Stage 2 ice (hereafter Stage 2).
3. Only limited retreat moraines were found in the WCR and the few cirque moraines were considered to be older than Younger Dryas-type moraines in, for example, the mountains of the British Isles.

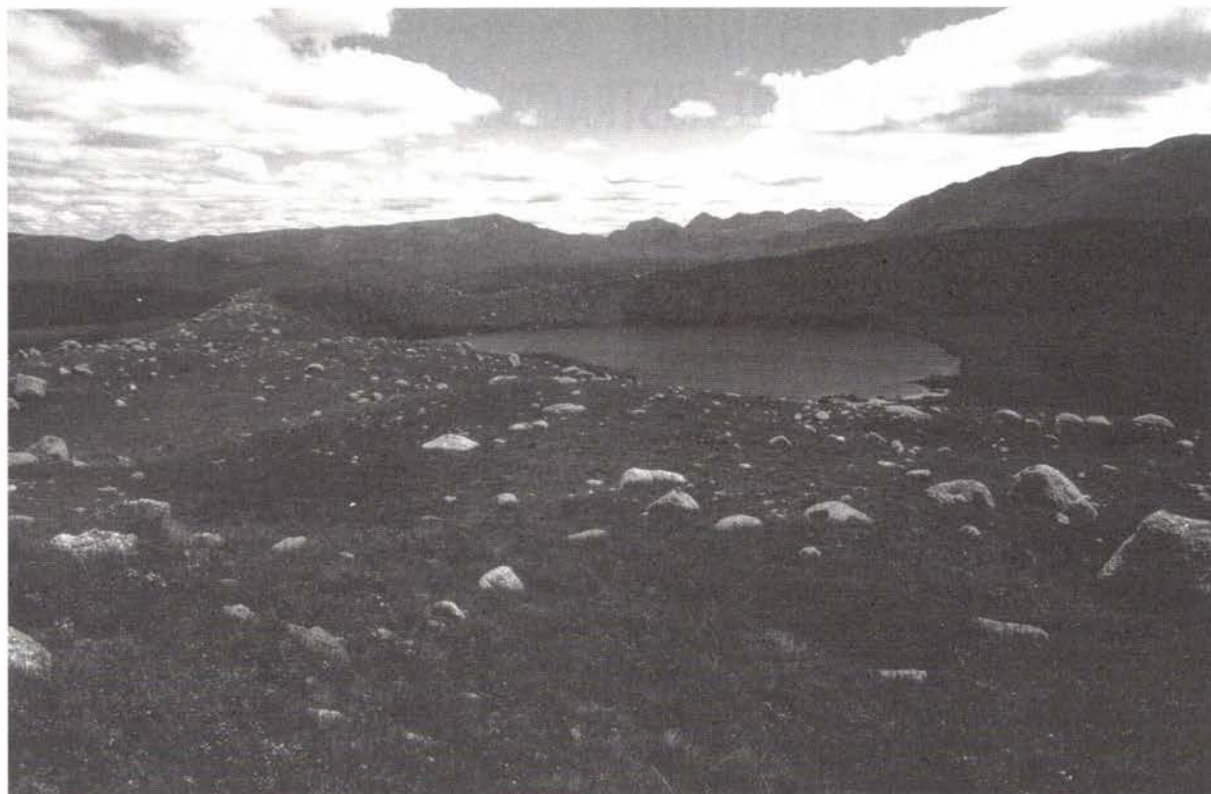
4. A sequence of organic-rich clays dated from 23,640 \pm 1030 yr BP (GaK 5597) to >34,600 yr BP (GaK 5595) was found to overlie till at Henty Bridge. This till was thus older than Stage 2 and wood from its surface was amino-acid assayed at Stage 6. The term Henty was given to the glaciation.

5. Examination of weathering-rind thicknesses on dolerites from tills in the WCR gave 3 populations. These were associated with the Last, Henty and a Linda Glaciation, the Linda being characterised by very weathered and widespread glacial deposits.

A new 3-fold model was established by 1983 that was different from the Lewis model but there was now a need to find out if the new model applied to all of Tasmania or whether there was a still more complex history of glacial events. During the mid and late 1980s research by Paul Augustinus in the Pieman and Bulgobac valleys northwest of the WCR, Sean Fitzsimons in the King Valley southeast of the WCR, David Hannan in north central Tasmania, Kevin Kiernan in south central Tasmania and later by Andrew Mackintosh at Mount Field enhanced the evidence greatly. In addition, pollen analyses of interglacial and interstadial organic deposits by Eric Colhoun, Guus van de Geer and Michael Macphail, amino-acid dating by Brad Pillans, soil studies by Andrew Hammond, plus geomagnetic dating of lake clays associated with the glacial events by Michael Pollington, Michael Barbetti and Charlie Barton, gave greater certainty to the stratigraphic and temporal dating of the glacial sequences that were too old for radiocarbon dating.

The outcomes included recognition of:

1. Glaciation during both Stages 2 and 4 in the upper King Valley.
2. Multi-stage glaciation in the WCR, north central and south central Tasmania, including the Pieman, King, Mersey, Forth, upper Derwent, Franklin and upper Gordon valleys during the Middle Pleistocene, indicated by moderately weathered glacial deposits associated with lake clays of normal magnetisation.



The Hamilton End Moraine is the largest in Australia. The main ridge was formed during OIS 6, but it is a complex structure with deposits belonging to earlier glaciations. The lake, Basin Lake, is very shallow and is formed in the distal part of an outwash apron deposited from OIS2 end moraines at Poets Hill, which is just east of the photograph and west of Lake Margaret. The Tyndall and other mountains that form part of the West Coast Range of Tasmania to the north are visible in the background. (Photo: E. Colhoun)

3. At least one and possibly several glaciations of Early Pleistocene age distinguished by widespread extremely weathered glacial deposits and associated lakeclays. These deposits have reversed magnetisation, indicating an age older than the Brunhes-Matuyama Boundary (782 ka). They are thought to be around 0.9 Ma in age.

Thus, by the late 1990s it had been established that the glacial history of Tasmania included many ice advances during the Late, Middle and Early Pleistocene, and that the record spanned most of the last million years.

During the last decade, application of cosmogenic isotope dating combined with concern for understanding the timing of maximum ice expansion and final deglaciation in the southern and northern hemispheres has given new impetus to refining the events of the Last Glaciation. The cosmogenic dating has been undertaken by two groups of researchers based on ANSTO and ANU, and led by David Fink and Tim Barrows respectively. The joint outcomes have demonstrated that:

1. The maximum of Stage 2 occurred around 19-21 kyr BP.
2. There was very rapid deglaciation following the maximum between 18 and 16 kyr.
3. Little, if any, ice remained in Tasmania after 15 kyr BP, and there is no evidence for either an Antarctic Cold Reversal or a Younger Dryas event.
4. Dates older than Stage 2 but within the age range of Stage 3 occur on the eastern part of the Central Plateau, north of Lake Rolleston in the WCR, in the Broad Valley at Mt Field and north of Schnells Ridge. The dates point to ice presence at times during Stage 3.
5. The Hamilton End Moraine, the largest moraine in Australia, has been dated to at least Stage 6 age, and is shown not to have marked the limit of Stage 2 ice west of Lake Margaret in the WCR.

The dated evidence for glacial events during the Last Glaciation in Tasmania does not indicate significant synchrony with events in the northern hemisphere.

AQUA '04 CRADLE MOUNTAIN PRIZEWINNING STUDENT ABSTRACTS

Evidence for a faunal refuge in the Larsemann Hills, East Antarctica, during the Last Glacial Maximum

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Recent evidence from dating of sediment cores indicates that the magnitude of the Antarctic ice sheet during the Last Glacial Maximum (LGM) was not as extensive as previously thought. Several areas of Antarctica are now known to have remained ice free during the LGM, and may have acted as lacustrine refugia for the freshwater lake fauna during this time. This has significant implications for theories on the origins of the current Antarctic freshwater lake fauna. It had been previously assumed by some that all freshwater lakes were colonised by dispersal of species from sub-Antarctic islands, or more northerly continents, after Holocene deglaciation. The occurrence of refugia suggests that the communities found in some freshwater lakes today may be relict populations from pre-glacial times, and can perhaps provide information on the biota of Antarctica prior to the onset of glaciation.

The Larsemann Hills, East Antarctica (76°23'E; 69°23'S) is one area now known to have been ice free throughout the LGM. This region is a rocky oasis of approximately 40 km². It consists of two main peninsulas, Stornes and Broknes, that contain

around 150 freshwater lakes. In general the lake fauna is dominated by microzooplankton species such as rotifers and tardigrades, and many lakes contain populations of the Cladoceran, *Daphniopsis studei*, which is the only crustacean to currently inhabit lakes in this region.

Current theories on the deglaciation of the Larsemann Hills have the majority of Broknes as well as several islands ice-free as far back as MIS 5e (Hodgson et al. 2004). Extrapolated dates on basal sediments from Lake Reid (Figure 1), a small, shallow lake on Broknes, have yielded ages of approximately 130 000 yr BP. In this study we searched for faunal remains in these very old sediments and in more recent sediments to determine if faunal communities were present prior to the LGM and if the lake was a refuge for these species during the LGM.

A study on a sediment core from Lake Reid found several interesting shifts in fossil pigments and the diatom communities throughout the core (Hodgson et al., 2004). A range of sub-Antarctic diatom species, indicative of warmer and wetter conditions, were prevalent in the basal sediments. This corresponds to conditions suggested for Antarctica during the MIS 5e interglacial. Communities then became dominated by more arid, cold tolerant species indicating the onset of the glacial period. At approximately 26 000 yr BP, however, a large shift from a multi-species diatom community through to a monospecific one indicated the onset of the LGM. This persisted into the Holocene deglaciation, when several species recolonised resulting in communities similar to the modern day. These dramatic changes in the primary producers would have had a major effect on any faunal communities present in the lake during this time. We would therefore expect that, given appropriate conditions for preservation, any changes in these faunal communities would be paralleled by changes in the faunal remains present in the lakes sediment.

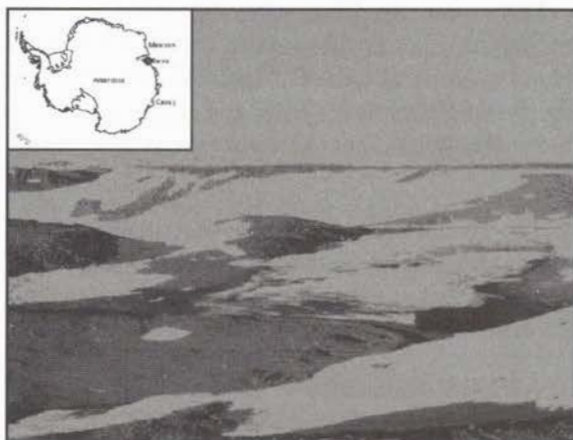


Figure 1: Lake Reid in the Larsemann Hills, east Antarctica.

To isolate faunal remains, sediments dispersed in distilled water, stained with Rose Bengal and washed through a set of stacked sieves (200, 100 and 44 μm). The sediments were then sorted under a dissecting microscope and any remains were counted, described and photographed.

The remains found in the core from Lake Reid included the lorica of the rotifer *Notholca* sp.; the mandibles and spermatophores of an unidentified copepod; the ephippia, post-abdominal claws and mandibles of the Cladoceran *Daphniopsis studei*; and eggs and claws of tardigrades. There were also several as-yet unidentified egg types.

The remains found in the most recent sediments correlate well with the documented present-day communities of rotifers, tardigrades, *D. studei* and several unknown egg types, which are most likely to be rotifer eggs. However, this community has not been stable throughout the lake history (Figure 2).

The basal sediments of the Lake Reid core contained remains from *D. studei*, *Notholca* sp. and also the unidentified copepod. The presence of these remains in the very oldest sediments suggests that following development of the lake basin, colonisation occurred from a local source, rather than from long distance dispersal. The dominance by these two crustaceans appears to have continued throughout the interglacial and into the glacial period, however, with the onset of the LGM the copepod species

became extinct in the Lake Reid basin. This local extinction correlates with the major changes seen in the diatom community at this time, from a multi-specific to a monospecific one, in addition to a major crash in total primary productivity. It appears likely that either the food source of the copepod was wiped out, or that the copepod was out-competed for food and other resources, by *D. studei*, which appears to have persisted in the lake throughout the LGM. It is most likely a combination of these factors.

From the distribution of faunal remains it appears that Lake Reid did support faunal communities throughout the LGM, and in fact well into the interglacial of MIS 5e. The colonisation of Lake Reid by at least some the species currently present, notably the rotifer *Notholca* sp. and the cladoceran *Daphniopsis studei*, did not occur during the Holocene through long distance dispersal. These species have been associated with Lake Reid, the Larsemann Hills and Antarctica for over 100 000 years, and are relict pre-glacial species.

Reference

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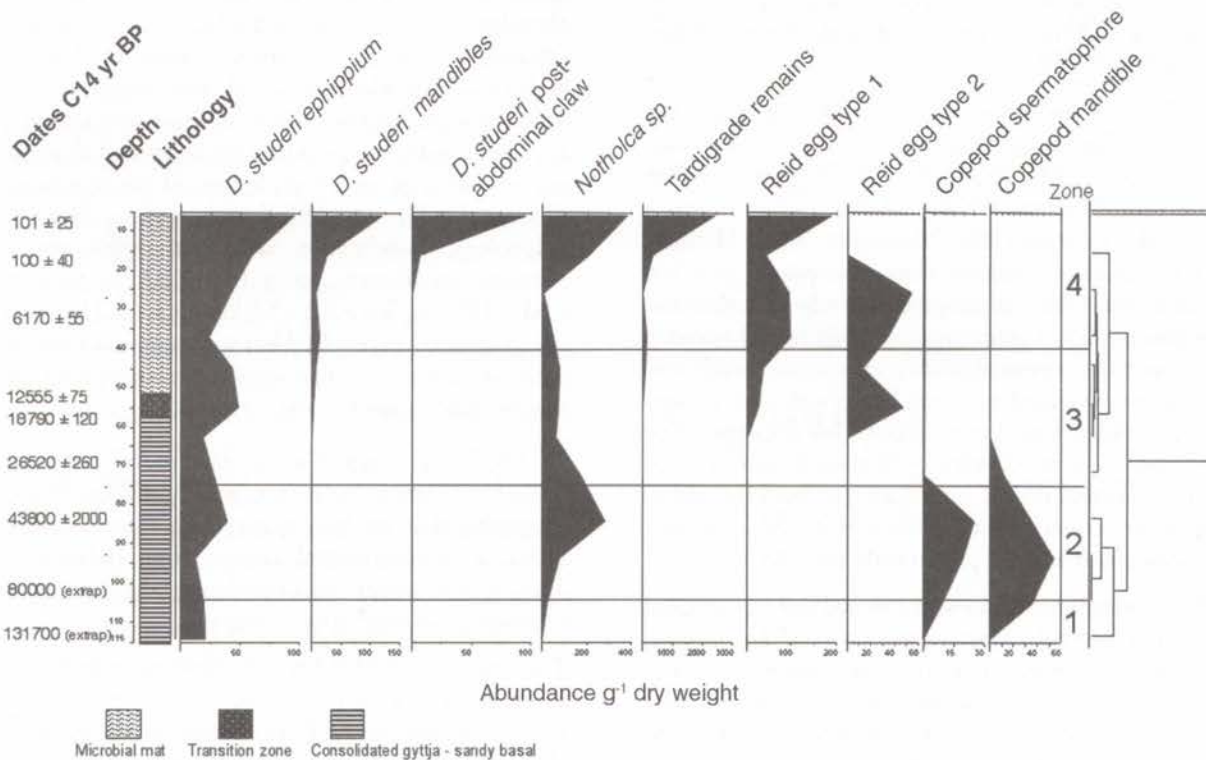


Figure 2: Abundance of zooplankton remains (g-1 dry sediment) versus sediment depth and age.

AQUA '04 CRADLE MOUNTAIN PRIZEWINNING STUDENT ABSTRACTS

Holocene fire history from the Greater Blue Mountains World Heritage Area, New South Wales Australia: the climate, humans and fire nexus

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There are several poorly understood issues regarding the history of fire in the humid environments of south-eastern Australia. These include claims that the manipulation of fire by Aboriginal people was a significant feature of pre-European times. This study presents a reconstruction of the fire activity of the last ~14.2 kyr from Gooches Crater Right (GCR). Charcoal analysis, palynology, humification and stratigraphic analysis were undertaken with the aim of untangling any inter-relationships between climate, humans and fire. The study also aimed at contributing to the management of fire in the contemporary environment. The study forms a part of a larger project that seeks to disentangle the fire, humans and climate nexus within the Sydney Basin, New South Wales.

GCR is located at an altitude of 960 m asl on the Newnes Plateau, approximately 150 km to the west of Sydney (~33°27'S, 150°16'E). The site is within the Blue Mountains National Park, which forms a part of the Greater Blue Mountains World Heritage Area. GCR is a narrow, elongated swamp in a low headwater valley adjacent to Gooches Crater, and contains ~6 m of sandy organic sediments. The swamp is currently vegetated with a closed wet heath and eucalypt woodland and open heath surround the site. Archaeological evidence suggests that the upper Blue Mountains were occupied by humans from at least 14 ka. Aboriginal people were displaced from the region with the arrival of European colonists and associated diseases such as small pox in early the 1800's.

A 3.55 m sediment core was retrieved and sub-sampled at 5 cm intervals. Macroscopic charcoal (>250 µm), thought to represent local or catchment fires, was analysed using a modified version of the 'Oregon sieving method' (as described by Mooney and Black, 2003). Charcoal was quantified using counts (per cm³) and as an area (cm²/cm³) using image analysis. Pollen

samples were prepared using standard palynological techniques (Faegri and Iverson, 1975). Pollen and spores were also quantified to examine aspects of the vegetation through time. A fire index was formulated by dividing the total number of palynomorphs of fire promoted vegetation by fire sensitive groups. A chronology of the site was provided by radiocarbon dating. The degree of humification of the samples was analysed using a modified version of Aaby (1986).

In the late glacial-Holocene transition charcoal was variable including a peak between the Antarctic Cold Reversal (~14.5 to 12.9 ka) and the Younger Dryas stadial (~12.7 to 11.5 ka). Charcoal was less abundant between ~9 ka and 6 ka, however this was followed by a relatively abrupt increase in charcoal at 5.5 ka, after which charcoal then remained high until ~3.4 ka. Another abrupt increase occurred at 3 ka. The post-European period has witnessed charcoal accumulating at very high levels. These trends are illustrated in Fig. 1. CONISS analysis of the charcoal, palynology, humification and stratigraphic results revealed six discrete zones (~AD1820 – present, ~AD1820 – 3.2 ka, ~3.2 – 5.5 ka, ~5.5 – 7.3 ka, ~7.3 – 11.1 ka and ~11.1 – 14.2 ka) with a significant shift ~5.5 ka. There was a positive correlation between the fire index and charcoal.

At GCR the vegetation appears to be relatively resilient to climate but is more greatly affected by fire, suggesting that fire history may be a more sensitive index of environmental change than palynology. This is not surprising considering the fire-prone sclerophyllous vegetation of the site.

This study has highlighted an apparent increase in fire activity during periods of climate change, for example during the ACR-YD transition and the mid-Holocene. Haberle et al. (2001) came to a similar conclusion in Melanesia.

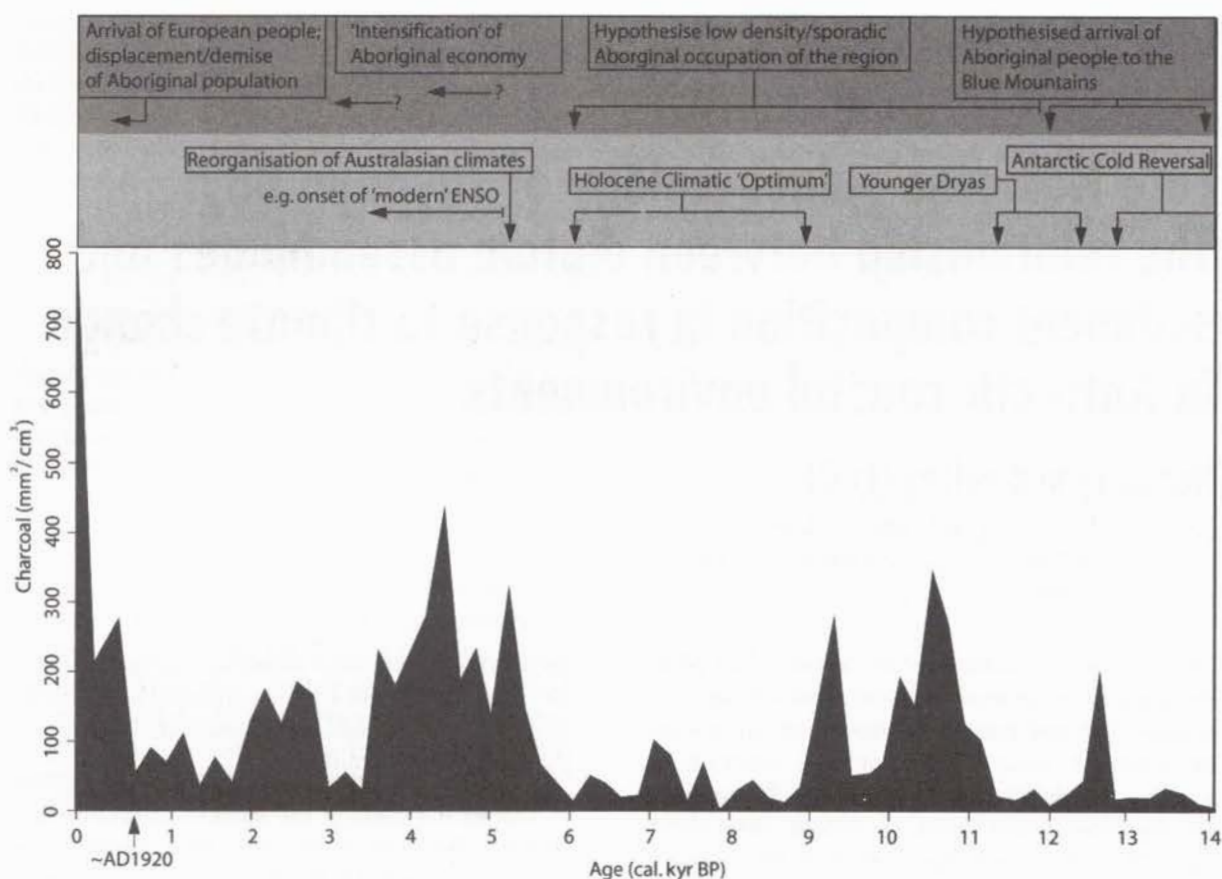


Figure 1. Charcoal curve for GCR annotated with potential climatic and anthropogenic influences.

Despite the potential interactions between climate, humans and fire over the last ~14.2 ka climate appears to be the dominant control of fire activity at Gooches Crater Right (this is not true, however, in the recent historic past, which has a high fire activity without precedent in the previous ~14.2 ka). The suggestion that climate is a dominant control of fire activity in south-eastern Australia is very much at odds with the prevailing paradigm which depicts Aboriginal people as controlling regimes in the pre-European period. This conclusion may also imply that the use of fire for resource manipulation by Aboriginal people in the Sydney Basin has been overstated. Bowman and Brown (1986, p. 166) have previously suggested that fire-stick farming had received "too little critical examination", with attendant circular arguments and hence it had become a "self-fulfilling prophecy".

The study suggests a more complex view of past fire activity rather than a simple dichotomy between the pre- and post-European periods. This means that any strategy advocating a return to some semblance of the pre-European fire activity is overly simplistic.

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Late Holocene palaeoecology of Taynaya Bay: The relationship between diatom assemblages and sediment composition in response to climate change in Antarctic coastal environments

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Taynaya Bay, in the north of the Vestfold Hills, East Antarctica, is composed of six marine basins. Its shallow sills and partial isolation from the marine environment make it particularly sensitive to climatic variability, and its meromictic basins allow for excellent preservation of diatom assemblages that reflect this variability. The initial major aim of this thesis was to develop an understanding of the environmental processes influencing the sediment composition and sedimenting diatom assemblages in the modern environment of Taynaya Bay, and the relationships and environmental feedbacks between these physiochemical and biological variables. The second objective was to determine past environmental and climatic change by applying information collected in the modern environment to the variability in sediment composition and diatom assemblages found in sediment cores collected from Taynaya Bay.

In order to achieve the first aim, two studies of the modern environment in Taynaya Bay were undertaken. The first was to monitor the physical, chemical and biological processes operating through the late spring and summer, from November 13, 1997 to February 3, 1998, in the water column in Taynaya Bay. This was undertaken to determine the main environmental processes and relationships between variables affecting the sedimenting diatom assemblages and the final composition of the sediment at the study site. Changes in the diatom assemblages were found to be closely tied to several inter-related variables. Diatom assemblages correlated closely with ice thickness and melt, but also with a fall in nitrite+nitrate levels (along with silicate and phosphorus), and rising water temperature through the recorded period. These factors were influenced by the meteorology of the region. Of the

meteorological variables measured, changes in weekly air temperature most closely correlated with changes in the diatom assemblages through its influence on the water column variables.

In the second study of the modern environment in Taynaya Bay, surface sediment grab samples were collected throughout the Bay to determine spatial relationships between sediment composition, diatom assemblages and environmental variability. Analysis of the data collected indicated that the proportion of sand versus biogenic opal deposition had the greatest influence on the sediment variation, while the C:N ratio was also highly significant. However, diatom assemblages in surface sediment samples correlated most closely with the proportion of carbon (versus sand) in the sediment and the distance from the entrance to the Bay (related to variables induced by degree of isolation from the sea). Sand (related to substrate), water depth (indirectly related to light) and entrance distance had the closest relationships to variability in the benthic diatom communities.

In order to achieve the second aim, high resolution multiproxy analysis was undertaken on three sediment cores from different environments within Taynaya Bay. The first sediment core, TB1, was from the slope of a basin, which is not currently meromictic. Sediment core TB1 is 58 cm long and was dated using ^{14}C AMS from 4.8 ka to present, and has poor diatom preservation from 26 cm to 48 cm. The second core, TB2, was from a deep (42 m) meromictic basin, and is 191 cm long. The base, middle and top of TB2 were dated using ^{14}C AMS. The top 25 cm of the core and two frozen sediment spade cores collected adjacent to it were dated using ^{210}Pb . This produced an age range for the core of 1.1 ka to the present. In this core, $\delta^{13}\text{C}$, which indicated

phytoplankton productivity and its limitations, was found to have the closest relationship to trends in the diatom assemblage. The third sediment core, TB3, was from near the meromictic boundary of a relatively shallow (18 m) basin. TB3 is 266 cm long, and was dated from approximately 4 ka to present using ^{14}C AMS. In this core the amount of carbon, and secondarily the amount of biogenic opal (versus sand), had the closest relationship to the diatom assemblage. This pattern was largely associated with an inverse relationship between benthic species abundance and sea ice diatom preservation, which is a response to the presence or absence of meromixis. The presence of meromixis over the site was related to changes in clastic deposition indicating changes in the flow of water into the basin, and related circulation changes.

The analysis of information from the three sediment cores provides a record of past climatic events in the region throughout the last 5 ka. The three records together indicate the presence of two warm periods between about 4.8 ka to 4.6 ka, and about 3.85 ka to about 2.5 ka. The later of these has three particularly warm periods which were tentatively dated from 3.85 ka to 3.65 ka, 3.3 ka to 3.1 ka, and 2.8 ka to 2.55 ka. Stepwise changes to a much cooler environment occurred in the sediment cores between 2.5 ka and 2 ka. Some of the changes in sediment composition and diatom assemblage were consistent with a cooling environment starting from 2.5 ka, while others suggested a later start for this cooling, just before 2 ka. From about 2.2 ka there is evidence of a cool

“Neoglacial” period lasting until about 1.3 ka. From 1.3 ka the diatom and sediment data suggest a warm period in Taynaya Bay, within which the warmest period lasted from 1.1 ka to about 900 BP. From this time a gradual cooling began, with distinct changes occurring within the cores at around 850 BP, 700 BP, 500 BP and 400 BP. Diatom assemblages suggest this gradual cooling was punctuated by short (50–100 year) slightly cooler and warmer periods between c. 820 BP and 550 BP. High resolution analysis of the diatom assemblage (one sample encompassing c. 6 years of deposition) showed that from 400 BP there is evidence of a particularly cool climate, with marked fluctuations interspersed with short periods of warmer climate. The coolest event within this time period is centred on 200 BP. From 100 BP to the present, indicators within the cores suggest a warming event, some trends of which are similar to those of the warm period between 1000 BP and 900 BP.

This high resolution reconstruction aids in tying together the often shorter lake core records, the coarse resolution marine core records, and geomorphological evidence of late Holocene climate change in the region. The record compares well with the shorter term high resolution ice core records from Law Dome, and also indicates the impacts of the recorded changes on coastal environments and their ecology. This study also takes a major step toward determining the environmental preferences and sensitivities of Antarctic benthic diatom species, the study of which has previously been largely neglected.

THESES ABSTRACTS

Geochemically tracing the intermediate and surface waters in the Tasman Sea, southwest Pacific

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The relatively understudied intermediate waters of the world have been implicated as an important part of the global ocean circulation. This thesis discusses the intermediate waters of the Pacific. Initially using geochemical tracers to look at the present distribution, sources and mixing. Secondly using carbon isotopes from a sedimentary marine core to study changes in the Antarctic Intermediate Waters (AAIW) and the East Australian Current (EAC) surface waters over the last glacial/interglacial transition in the north Tasman Sea, southwest Pacific.

The geochemical tracers highlight the presence of three separate intermediate water masses in the Pacific; the North Pacific Intermediate Water (NPIW), AAIW and the Equatorial Intermediate Water (EqIW). The EqIW has previously been considered an extension of the intermediate water masses to the north or south. The distinct geochemical characteristics of EqIW indicate that it cannot be formed by direct mixing of the NPIW and AAIW. The tracers suggest the EqIW must also include mixing with nutrient rich oxygen deficient, Old Pacific Deep Waters (PDW).

The AAIW distribution and circulation show a primary formation region in the southeast Pacific. The high oxygen, low salinity signature of this southeast Pacific source is altered during its circulation of the subtropical gyre. This is the result of aging during circulation and mixing with other intermediate waters entering the region. A second source region is the eastern equatorial Pacific (EEP), where there is mixing with old, nutrient rich EqIW. Mixing between the EqIW and AAIW is evident as far south as 30°S. The data also suggests a tongue of EqIW, overlying and mixing with the upper layers of the AAIW, continuing to flow south adjacent to the South American coast. A third source of AAIW enters the south Tasman Sea directly from the Southern Ocean. This third source has little influence on the main subtropical gyre, however it contributes to the geochemistry of the Tasman Sea and Coral Sea intermediate waters.

The uniformity of the AAIW in the Tasman Sea and Coral Sea advocates for a separate recirculating gyre in the southwest Pacific.

The main exit of AAIW from the south Pacific is either through mixing to form the EqIW along the equator, or south to the east of the Tonga-Kermadec Ridge following the subtropical gyre circulation.

This present day distribution of the intermediate water masses and their geochemical variations, specifically the carbon isotopes, allows the interpretation of paleoceanographic data sets where carbon isotopes can be measured directly from the calcitic foraminifera tests.

A series of marine sediment cores were collected from a depth transect along the Capricorn Channel (~23°S) in the southern Great Barrier Reef (GBR). The sedimentary data from these cores provide a preliminary model of hemipelagic deposition within this region over the last glacial/interglacial sea level cycle. The sedimentary evidence highlights the importance of the bathymetry, especially the morphology of the reef platforms and the continental shelf, to understand hemipelagic sediment systems. Compared to models from the mixed carbonate/clastic systems of the northern GBR, the Capricorn Channel continues to be influenced by terrestrial sediments during the glacial lowstand. These terrestrial sediments are primarily distributed by the Fitzroy River system, which meanders across the continental shelf and flows into the channel.

The sediments in the Capricorn Channel appear to be focussed at intermediate water depths, possibly related to an increase in the slope gradient. This provides a high sedimentation rate core (FR1/97 GC-12) to look at relatively high-resolution paleoceanographic variations during the last deglaciation. Stable isotope results were analysed on a suite of planktonic foraminifera (*Globigerinoides ruber*, *Globigerinoides sacculifer*, *Globorotalia menardii*, *Globorotalia truncatulinoides*) and benthic foraminifera (*Cibicides*

spp.), to highlight changes in the water column throughout this period. Comparison of the $\delta^{13}\text{C}$ data from the different species were used to determine changes in the ocean circulation and display three distinct phases 1) Glacial, 2) Deglaciation 18-12 ka BP and 3) Holocene 12-0 ka BP.

1. During the glacial there is a large $\Delta\delta^{13}\text{C}$ planktonic-benthic difference of 1.1‰, implicating a well stratified surface to intermediate depth ocean. Abundant *Gr. menardii* and *Gr. truncatulinoides* suggest that the thermocline was shallow and the intermediate waters were thick. The AAIW in the Tasman Sea appears to be dominated by the southern source, directly from the Southern Ocean and maybe mixing with the underlying nutrient rich deep waters.

2. At ~18 ka BP there is a sudden collapse in the $\Delta\delta^{13}\text{C}$ planktonic-benthic offset to ~0.4‰. This is the result of rapid ventilation event in the AAIW and a switch from the southern source to the northeast source water in the Coral Sea. During this phase the *Gr. menardii* and *Gr. truncatulinoides* decrease in abundance and the *G. ruber* and *G. sacculifer* return to prominence. The $\delta^{13}\text{C}$ planktonic minimum is evident over a wide geographic extent and the AAIW has been implicated as the driver for the release of deep water CO_2 and the main conduit for transporting this preformed $\delta^{13}\text{C}$ signal within the Southern Hemisphere ocean basins. This $\delta^{13}\text{C}$ planktonic minimum correlates with the rise in atmospheric CO_2 measured in ice cores.

3. At ~12 ka BP the $\Delta\delta^{13}\text{C}$ planktonic-benthic offset begins to recover and reaches modern values of 0.7‰. This is possibly related to the onset of the NADW formation and the return to present day thermohaline global ocean circulation.

The $\delta^{18}\text{O}$ data from the *G. ruber* from the same core (FR1/97 GC-12) was also compared with another high sedimentation rate core RV105 GC-25 from ~26°S in the Tasman Sea. The differences in the $\delta^{18}\text{O}$ values highlight variation in the surface current, the East Australian Current (EAC) during the last deglaciation.

The EAC is the western boundary current (WBC) of the south Pacific subtropical gyre and important for

modulating the climate of eastern Australia and New Zealand. Like all WBCs it separates from the coast at a particular location and flows out to sea in an eastward jet, the Tasman Front. Recent modelling suggests the reason for the EAC separation and formation of the Tasman Front is related to a rapid gradient in the zonally integrated wind stress curl at this latitude. The $\delta^{18}\text{O}$ *G. ruber* data from GC-12 exhibits a 1.5‰ decrease between the last glacial maximum (LGM) and present. Taking into account ice volume and assuming no salinity changes this represents a temperature difference of 2-3°C, comparable to the estimates from foraminiferal abundances. RV105 GC-25, a core from ~3° south of GC-12, displays a 2.2‰ decrease since the LGM, suggesting an ~6°C difference compared with present sea surface temperatures (SSTs). This large temperature gradient of 3-5°C in ~3° latitude is similar to the temperature gradient evidence across the Tasman Front today. This suggests that during the LGM the EAC separation occurred north of RV105 GC-25 at ~26°S. Paleo-evidence suggests that there is considerable weakening of the trade winds as a result of a reduction in the equatorial east-west SST gradient. There is also increasing evidence to suggest a 3-5°S equatorial shift of the subtropical westerlies, combined with a strengthening of the westerlies especially in the south. These changes in the winds would have had a considerable affect on the wind stress field and consequently the wind stress curl of the south Pacific, potentially causing the EAC separation to shift as far north as 26°S.

A rapid convergence of the $\delta^{18}\text{O}$ *G. ruber* data from FR1/97 GC-12 and RV105 GC-25 is evident between 12-11 ka BP suggesting the EAC was forced south of 26°S at this time. This shift is synchronous with a rapid warming in the tropical SSTs at the end of the Younger Dryas and the onset of a La Niña-like state in the Pacific. This change in the east-west SST gradient would have enhanced the easterly trade winds, altering the wind stress field. The EAC separation would have readjusted accordingly. This marks the onset of modern circulation in the southwest Pacific. Present EAC flow, however, was probably only achieved when complete modern conditions, including present day El Niño Southern Oscillation (ENSO) periodicities, are achieved after 5 ka BP.

THESES ABSTRACTS

A Sediment Based Approach to Human Impact at Lake Bonney S.E. South Australia

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Water conditions in Lake Bonney in the South East of South Australia have been of concern for a number of years, due to contamination of the waters by effluent discharged from a pulp and paper mill, currently operated by Kimberly – Clark Australia Ltd. In 2004, the EPA initiated a project that aimed to investigate the environmental effects of these discharges and other impacts. Their aim was to develop strategies to remediate the lake, and develop new environmental guidelines for effluent disposal at the mills, in advance of the expiration of the operating license on 7th October 2014.

A component of this task was the reconstruction of the past water quality of Lake Bonney using palaeolimnological techniques, with a focus on the time since European settlement. Diatom analyses from a sediment core were used to determine the salinity history of the lake, and to characterise the nature and timing of major changes in the lake's nutrient concentrations since European settlement. An additional and complementary analysis of a sediment core taken from Mullins Swamp (a remnant

of Lake Frome) situated north-west of Lake Bonney, was used to determine the extent to which this site represents an unimpacted control site. Lake Bonney and Mullins Swamp were both found to be naturally brackish, shallow lakes in the pre-European phase. Lake Bonney has undergone two shifts in the post-European phase; at the commencement of drainage in the 1860s, and at the commencement of pulp and paper production in 1942. By the top of the record, the lake had become eutrophic.

Mullins Swamp has experienced a dramatic change as a result of drainage works in the mid 1860s, shifting from a seasonally shallow, brackish water body, to a fresher and frequently deeper lake. It did not support the nutrient indicator taxa of Lake Bonney, and so represents a control only in so far as it possibly reflects what Lake Bonney may have been like if had it not been affected by the effluent from the mills. However, both water bodies show substantial modification as a result of changes in surface drainage water, and neither can be said to be unimpacted.

Late Quaternary Environments of the Murray River Valley in Northwestern Victoria

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A multidisciplinary approach has been employed to study the complex environmental and cultural evolution of the Victorian Mallee. Regional geomorphic mapping of relict landforms, archaeological survey and stratigraphic analyses reveal evidence of ongoing climatic oscillations in the Neds Corner region, where the Murray River system interacts with aeolian Mallee landscapes.

Analysis of landforms using a land systems approach provides new insights into patterns of fluvial-aeolian interaction over the last glacial cycle. Five land systems are identified within the study area; three of these preserve evidence of palaeochannel activity markedly different from the present Murray River system. Fluvial morphology evolved over the late Quaternary from wide, laterally-migrating channels

associated with source-bordering dunes to narrower, more sinuous regimes. An extensive archaeological record overprints the region, with radiocarbon and optically stimulated luminescence (OSL) dating revealing human presence in this landscape from at least 15,000 cal-yr BP.

The micromorphology of dated late Pleistocene mussel shells (*Alathyria jacksoni*) collected from an excavated Aboriginal shell midden were studied using scanning electron microscopy (SEM) and cathodoluminescence (CL). Aragonitic growth band sequences have been interpreted as sub-annual growth cycles. Oxygen isotopic analyses from these cyclic

growth bands offer an estimate of the temperature, precipitation and evaporation conditions at the time of mussel shell growth, and thus are used as a proxy for palaeoclimate during late Pleistocene human occupation. Larger $\delta^{18}\text{O}$ amplitudes in the archaeological (3 ‰) compared to the modern (1.58 – 1.7 ‰) Murray River shells might reflect increasing seasonality, temperature change or the input of seasonal snow melt during the last deglaciation. Combining multivariate geomorphic, stratigraphic, geochemical and archaeological evidence, this study provides a temporally constrained model of environmental, climatic and cultural evolution in the Victorian Mallee of southeastern Australia.

The use of Ostracoda in the Palaeoenvironmental reconstruction of the Gulf of Carpentaria, Australia from the last interglacial to present

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Throughout the majority of the last glacial cycle, the Gulf of Carpentaria, the large body of seawater that extends as a broad tongue into the north of Australia, was an enclosed lake. It would have been possible to walk around the perimeter of the lake from Australia to New Guinea. Aboriginal oral tradition recalls that during some periods, the lake teemed with freshwater fish and waterfowl. At other times, it was shallow and segmented into a series of saline swamps and pools, or even dry and subaerially exposed. Marine waters transgressed the lake margins during periods of high sea level, forming a shallow marine embayment through to open marine conditions. A large brackish lake remained as the waters again receded. The present open shallow marine conditions were emplaced within the last eight thousand years.

Fluctuations in the extent and nature of this waterbody through the last glacial cycle are preserved in the sediments of the gulf. The sedimentological interpretation of core material retrieved from the gulf provides a framework of palaeoenvironmental change in the region, in particular the extent of the lake basin, timing of marine influence and evidence of channel activity. Through the detailed analysis of ostracod faunal assemblages of the core sediment and comparison with modern species distribution, inferences are drawn about the ecology of the gulf

basin at the time of valve formation. Morphological variation and preservation of the valves also provide information regarding the changing conditions of the waterbody and post-depositional effects. The geochemistry of the ostracod valves permits insight to variations in climate, particularly temperature and effective precipitation change. Comparison and correlation are made with the global sea-level curve and regional climatic records.

The implications for the range of environments evident in the gulf region through this period include the presence of warm shallow water for latent heat transport and the generation of cyclones, strengthened monsoon conditions and the mixing of Indian and Pacific Ocean waters through Torres Strait at high sea-level times, and greater continentality, reduced rainfall and altered oceanic currents during sea-level lowstands. The impact of the changing conditions, and shorelines, would have been particularly significant for the human inhabitants who have been present in this region for at least the last fifty thousand years. The nature and extent of the waterbody through the period has enormous implications for people, both as a resource for food and a potential land-bridge between Australia and New Guinea.

Holocene Geomorphology of the Macdonald and Tuross Rivers

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The floodplains that grade to the estuaries along the New South Wales coast primarily record a history of valley aggradation induced by post-glacial sea level rise. However, post-glacial sea level along this coast has both risen, then fallen, relative to the land during the Holocene due to isostatic compensation to loading of the ocean basins. Geomorphological and stratigraphic data from the Macdonald and Tuross valleys, which drain to this coast, are combined with radiocarbon and optically stimulated luminescence dating to examine how the floodplains of these coastal rivers have responded to such base level changes and also to the variable Holocene climate. From 9000 to 6000 years BP, as sea level was rising to its Holocene maximum, aggradation occurred in the alluvial reaches of both the Tuross and Macdonald rivers but at very different rates. In the Macdonald valley, aggradation occurred at 5.6mm per year, which greatly exceeded the 0.5 to 0.9mm per year rate of the Tuross valley. This difference reflects the shoreline transgression into the Tuross valley by rising sea level, whilst the Macdonald River, on account of its confined valley which was more conducive to sediment entrapment, was prograding.

When sea level stabilised 6500 years ago, progradation of the Tuross River was initiated, but continued to occur in the Macdonald valley. The aggradation that formed the highest and most extensive alluvial surfaces along the two valleys occurred between 6000 and 2000 years ago. The floodplain sediments of this period are comprised of slightly coarser sand

with less silt and clay than the underlying early Holocene deposits, and show weak pedogenesis. Aggradation in this interval occurred at 1.2 to 1.9mm per year in the Tuross Valley which was comparable with the 2 to 4mm per year rate of the Macdonald valley. The fluvial landforms such as the land-tied bars, levees and floodbasins built at this time are the dominant landforms of the present day valley floors. Aggradation of the alluvial reaches of both rivers was synchronous with progradation into their estuaries and demonstrates the link between these two processes.

The alluvial surfaces constructed by each river during the 6000 to 2000 year period were abandoned as active floodplains about 2000 years ago. This represented an important change in floodplain evolution and was accompanied by the construction of a mid-level bench inset below the abandoned floodplains. The relationship of the mid-level bench to this abandoned floodplain surface in each case is consistent with a climate change involving a shift to smaller floods occurring 2000 years ago. Consequently, it is concluded that this was the main reason these high floodplain surfaces were abandoned. However, subsequent abandonment of the Macdonald River's midlevel bench between 600 and 800 years ago, and the formation of a modern floodplain surface below it, are consistent with a stronger influence of post-highstand base level fall upon floodplain formation and evolution along this river.

Soil Stratigraphy and Chemical Characteristics of the Birdlings Flat Loess, Ahuriri Quarry, Banks Peninsula, Canterbury, New Zealand

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Loess deposits provide a record of paleoclimate conditions. Loess deposits accumulate during cold climate phases when increased erosion causes rivers to aggrade, which provides an increased loess source area. Loess deposits in South Island of New Zealand are often thick (up to 20 m) and commonly include buried soils, which are used to subdivide the deposits into distinct sheets. The loess sheets and the buried soils formed in them are interpreted as recording glacial and interglacial, or interstadial climate phases, respectively. Studies of loess have focussed on establishing the stratigraphy and more recently the age of the loess to provide a proxy climate record. Less attention has been placed on pedological features of buried soils, which have the potential to produce qualitative or even quantitative records of past climate change.

Birdlings Flat formation loess is a coarse-textured quartzofeldspathic loess found on the lower flanks of Banks Peninsula in Canterbury. An exposure at Ahuriri Quarry shows 12 m of strongly texturally-banded loess with pedogenic carbonate deposits throughout most of the loess below 2.5 m depth. In this study soil morphological features were used to define soil stratigraphic units that were traced and mapped across the exposed section. Four soil stratigraphic units, excluding the surface soil were recognised. Soil features are generally very subtle and much of the stratigraphic interpretation relied on the carbonate morphology. Former surface horizons

were recognised by concentrations of carbonate filaments or pseudomorphs emphasising the biofabric produced by root channels and burrows. Nodular carbonate accumulations were associated with these surface soil features in three of the soil stratigraphic units. Citrate dithionite-extractable Fe (Fe_d), soil pH and electrical conductivity (EC) analyses were carried out in order to corroborate the morphological identification of soil stratigraphic units. None was particularly successful: Fe_d appeared to respond as much to textural variability as to soil features; soil pH measurements were complicated by the overprinting of carbonate and salt accumulations from different phases of pedogenesis; and EC was confounded by an unknown complex interaction between carbonate and salts that reduced EC in regions where it was expected to be very high.

Optically stimulated luminescence (OSL) dating of the loess and radiocarbon dating of carbonate were generally consistent with each other and indicate the loess accumulated since about 35 000 years ago. The position and age of Kawakawa tephra (26 500 cal. yr BP), however, suggests that the OSL ages are underestimates. Comparisons of ages of loess and carbonate were used to estimate the depth of carbonate precipitation below the ground surface, which can be related to past precipitation. Results suggest rainfall decreased from the Last Glacial Maximum into the early Holocene, after which rainfall then increased to the level that carbonate was no longer precipitated.

Investigations Towards a Late Holocene Archaeology of Aboriginal Lifeways on the Southern Curtis Coast, Australia

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In this thesis I combine data from regional archaeological surveys and the excavation of eight stratified sites to examine aspects of continuity and change in the late Holocene archaeological record of the southern Curtis Coast, southeast Queensland, Australia. I focus on theoretical and methodological problems emerging out of studies in southeast Queensland, particularly the issues of chronology-building and assessment of site integrity.

Results of surveys and excavations are presented. Excavations were conducted at the Seven Mile Creek Mound, Mort Creek Site Complex, Pancake Creek Site Complex, Ironbark Site Complex, Eurimbula Creek 1, Eurimbula Creek 2, Eurimbula Site 1 and Tom's Creek Site Complex. Differences in site structure, content and chronology are used to establish a framework to describe variability in the regional archaeological record through space and time. Radiocarbon dates and items of European material culture indicate that occupation of these sites spans from around 4,000 years ago into the post-contact period. Dates were also obtained from several eroding archaeological deposits which were not subject to excavation. In total, 66 radiocarbon dates are presented from 12 archaeological sites.

Radiocarbon determinations are critically assessed to provide a reliable basis for calibrating radiocarbon dates into an absolute regional chronology. Local marine and estuarine reservoir effects are characterised through a study of known-age marine shell specimens and archaeological shell/charcoal paired samples. The object of the study was to assess the potential influence of localised variation in marine reservoir effect on accurately dating marine and estuarine shell from archaeological deposits in the area. Results indicate that the routinely-applied ΔR value of -5 ± 35 for northeast Australia is wrong. The determined values suggest a minor revision to Reimer and Reimer's (2000) recommended value for near-shore open marine environments in northeast Australia from $\Delta R = +11 \pm 5$ to $+12 \pm 7$, and specifically for central Queensland to $\Delta R = +10 \pm 7$. In contrast,

data obtained from estuarine shell/charcoal pairs demonstrate a general lack of consistency, suggesting estuary-specific patterns of variation in terrestrial carbon input and exchange with the open ocean. Preliminary data indicate that in some estuaries, at some time periods, a ΔR value of more than -155 ± 55 may be appropriate.

Radiocarbon determinations, stratigraphy and bivalve conjoin analyses are used to evaluate the integrity of the open shell midden deposits investigated for the project. Methods for identifying and interpreting bivalve conjoins in archaeological shell assemblages are developed and tested. Results indicate that contrary to the cautions of Lourandos (1996, 1997), the open sites studied exhibit a high degree of vertical and horizontal integrity.

Results suggest continuous restructuring of settlement-subsistence systems in the region throughout the late Holocene. A regional trajectory towards increased site occupation, intensity of site use, and localisation of resource use is identified. A three-phase cultural chronology is developed for the region which proposes initial occupation before 4,000 years ago and significant changes in resource use after 1,500 BP, including the widespread appearance of shellfishing and changes in stone raw material sources. Phase I (pre-4,000 BP–c.1,500 BP) saw ephemeral coastal occupation by groups which occasionally used coastal resources as part of a diffuse and highly-mobile settlement strategy covering a broad area. Land-using groups may have been primarily based around the predictable resources of major rivers such as the Boyne. Phase II (c.1,500 BP–c.AD 1850s) is characterised by intensive permanent and structured low mobility strategies throughout the coastal zone. This phase is defined by a localisation in the use of resources. Extremely large, low density archaeological sites are established throughout the region on the lower margins of major estuaries and smaller resources extraction sites are also established. Phase III (c.AD 1850s–c.AD 1920s) saw the emergence of post-European mobility systems.

Despite disappearing from the European historical record for the area, Aboriginal people continued to use traditional camping places well into the period of European settlement.

Results are discussed in the wider context of key themes in archaeological cultural chronologies proposed for southeast Queensland and adjacent

regions which emphasise recent changes in settlement and subsistence strategies linked to intensifying patterns of regional land-use. Patterns identified on the southern Curtis Coast generally concur with other findings from southeast Queensland, suggesting major restructuring of coastal occupation strategies in the late Holocene and especially the last 1,000 years.



PAGES MEETING

Overview of Palaeoscience in the Australasian Region – Report to the PAGES Scientific Steering Committee Meeting, Nairobi, August 2004

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PAGES achievements

The PAGES foci, especially PANASH, have provided a major framework and driver of Quaternary research in the Australia-New Zealand-Indonesian region over the last decade. This interest has culminated in the production of a special issue on the PEP2 transect (Dodson et al., 2004; see also perspective by Alverson, 2003). Individual contributions provide overviews and new insights into patterns of glaciation, dust transport, variations in the westerly wind systems, monsoons, the West Pacific Warm Pool, vegetation, and human migration and impact. A specific PEP2 issue was devoted to New Zealand (Shulmeister and Dodson, 2002). Because of the diversity of landscapes and major differences between the two hemispheres, few contributions have addressed the transect as a whole and this remains a future challenge.

With respect to the Australian region, a major development has been in the understanding of the evolution of the arid heart of the continent. Evidence from palaeolakes and rivers and dune systems (Hesse et al., 2004), along with long palynological records from the northern continent margin (Hope et al., 2004) derived mainly from cores collected on IMAGES cruises, are revealing a clear regional pattern of climate drying within the later part of the Quaternary. It could well be that this drying is a consequence of the continued northward movement of this 'dynamic

continent' into South East Asia and the impact it has had on land-sea relationships within the Maritime Continent region, associated developments in the West Pacific Warm Pool, and operations of ENSO and the Australian monsoon system. Vegetation feedbacks are considered important, especially since the arrival of people, some 50,000 years ago. Understanding these tectonic-climate-vegetation-human relationships has implications not only for the climate of this region but, through teleconnections, for the world as a whole. On more recent timescales, attention has been directed towards the relative roles of ENSO and people on mid Holocene environmental change, with additional debate over environmental or social causes of intensification of human occupation and impact (Haberle and David, 2004).

PAGES has also been influential at a regional level through its LIMPACS and HITES initiatives with active Australian representatives of both programs (Peter Gell and Henk Heijnis respectively). There has been a major focus on multiproxy, high resolution study of billabongs predominantly over the last 500 years, with the Murray-Darling Basin - the 'bread-basket' of Australia - being the major target. It illustrates well the major issues of climatic variability, river regulation, water shortages and salinisation that are evident over much of the continent.

PAGES MEETING

PAGES initiatives

There has been an inevitable lull in PAGES activities since completion of the PEP II publications but interest and involvement remain high. The Quaternary community is kept well informed of developments by regional representatives Paul Hesse (Australia) and Jamie Shulmeister (New Zealand) and by *Quaternary Australasia* edited by Kale Sniderman, and new initiatives are beginning to emerge.

One new PAGES-linked project is 'Orbital or thermal causes of glaciation in New Zealand' headed by Shulmeister, that is aimed at determination of the causes of glacial advances in New Zealand over the last 750,000 years, with a focus on the last 100,000 years. It proposes to test a new model of westerly wind forced glaciation against the existing NH thermal forcing model of glaciation. The two models would create dramatically different glacial worlds (wetter and milder versus drier and colder) and the results from this work will allow resolution of important questions on the link between glaciations in the two hemispheres and the role of the Southern Hemisphere westerlies in determining longer term global climate change.

A potential direction for the next cycle of PANASH is low-high latitude climate linkages and a symposium entitled 'Low-latitude and high-latitude climates and linkages in the Asia Oceania sector in the late Quaternary' was incorporated into the APGS Conference in Singapore this year. It brought together the nucleus of a new group that will drive the initiative forward. Future meetings have been set down for Beijing PAGES OSM (2005), Goa (2006) and Cairns INQUA (2007) with target publications set for each meeting. Jamie Shulmeister will give a plenary talk at the Beijing meeting on behalf of the PANASH community entitled 'Interhemispheric linkages in Climate Change: Paleoperspectives on modern problems'. In addition, Shulmeister is on the organising committee of a southern hemisphere focused AGU Chapman Conference 'Tropical-Extratropical Climatic Teleconnections: A Long-Term Perspective' held in Honolulu, Hawaii, February, 2005.

One of the major developments in 2004 was the opening of a New Zealand national web page on the PAGES web site. This site can be examined at <http://www.pages.unibe.ch/newzealand/index.html>. Perhaps the best feature of the site is the national science highlight.

The next LIMPACS working group meeting entitled "Salinity, Climate and Salinisation" will be held in Mildura, September-October 2004, in the heart of the Murray-Darling Basin, where environmental problems and research activities can be seen first hand. It is designed to set research priorities for 2005-2010 and is attracting substantial Australian as well as international interest.

INQUA initiatives

Two INQUA supported Palaeoclimate Commission projects that are very much related to PAGES activities and future links with PAGES are anticipated.

One project is Australasian INTIMATE (Integration of Ice-Core, Marine and Terrestrial Records), led by Shulmeister and Simon Haberle (AQUA president). It is a component of a geographical expansion of the highly successful INTIMATE programme, designed, through a number of international workshops, to seek the improvement of procedures for establishing the precise ages of, and effecting high correlations between North Atlantic climatic events of the Last Termination. Preliminary separate workshops in New Zealand and Australia have been held to identify and prioritise activities (see OZ and NZ INTIMATE reports in this issue - Ed).

The second initiative is 'Land-Ocean Correlation of Long Quaternary Records from the Southern Hemisphere' that clearly extends beyond Australasia. This will address the unique climatic history of the southern continents and oceans that, with their association with ENSO, monsoon generation, and their role in the global thermohaline circulation, are critical to the understanding of global climate change. The programme has attracted a great deal of interest internationally. Because of the distances involved between the southern continents and the active involvement of many from the northern hemisphere, the first international meeting will be held in association with the PAGES-DEKLIM Conference in Mainz, Germany in March 2005. There is a clear opportunity here to link the program with PAGES.

Results from these and other INQUA programmes will be presented in a number of symposia at the next INQUA Congress which will be in Cairns, 2007, in northern Australia.

Future Support

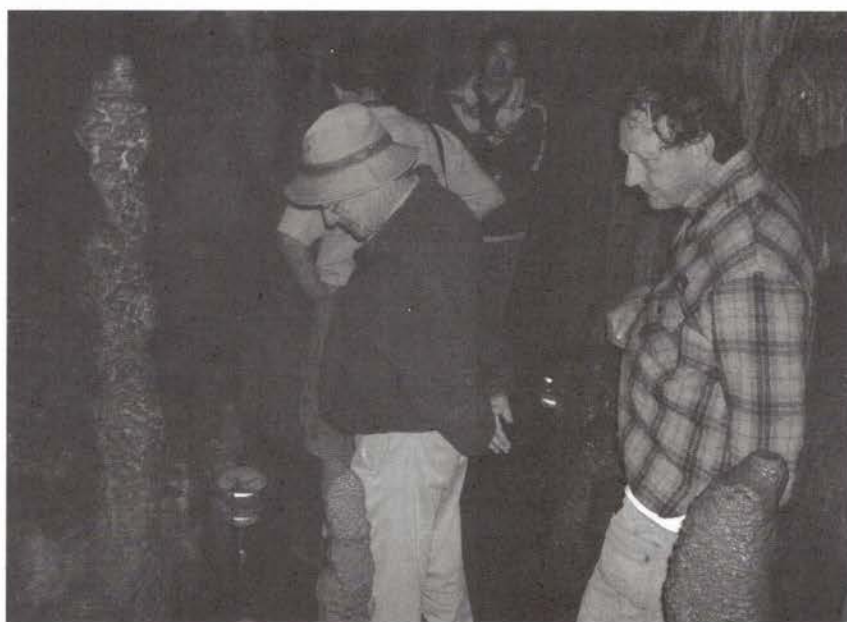
There is some optimism in Australia over potential government support, through the Australian Research Council (ARC), for selected aspects of palaeoresearch under the priority area 'A Sustainable Australia'. Palaeopeople are well represented on the recently announced successful ARC Network applications 'The ARC Earth System Science Network' that incorporates data collectors, modellers and impacts researchers to address the impacts of climate change and variability on human, biological and physical systems' and the 'Environmental Futures Network: Discovering the Past and Present to Shape the Future'. These will provide a total of about A\$3.5 million for meetings, data storage etc over the next five years. They will hopefully facilitate the acquisition of research grants and one application, 'Risks and Opportunities for Climate Change', is ready for submission for an ARC Centre of Excellence. Many initiatives will be assisted if two submitted ARC Linkage Infrastructure Equipment and Facilities (LIEF) grant applications are successful. One is for a facility associated with radiocarbon dating of specific compounds to improve reliability and accuracy of ages, while the other is for an ultra-sensitive radiocarbon analysis system that will produce refined radiocarbon dates rapidly and from very small samples.

Predictions from New Zealand are not as bright with palaeoclimate science sinking lower in government sights, and a number of active groups have had their

programs curtailed by government cuts. This has particularly affected a Landcare led program which has been a long-term contributor the PAGES-LOICZ (Land-Ocean Interactions in the Coastal Zone) project.

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Mole Creek Caves AQUA '04 field trip. (Photo: J.X. Zhao)

Towards an Australian Event Stratigraphy for the Last Termination

Summary of Oz-INTIMATE (INTEgration of Ice-core, Marine and TErrestrial records) workshop, ANSTO Lucas Heights, 6-7 September 2004

Chris Turney

University of Wollongong



Participants at the Oz-INTIMATE workshop, ANSTO, Lucas Heights, 6-7 September 2004.

Twenty-four Australian researchers attended the first Australian INTIMATE workshop meeting, hosted by ANSTO. There were two objectives of the meeting:

- Identify and prioritise Australian onshore and offshore reference records for the OIS 2/1 transition
- Promote ways to effect high-precision dating of key Australian onshore and offshore records for the determination of a regional event stratigraphy

The workshop spanned two days, of which more than half the time comprised presentations of records from across the southwest Pacific region. The records spanned the full range of depositional environments covered by INTIMATE, namely ice, marine and terrestrial. Simon Haberle (ANU) started the meeting by reminding the participants of the aims of the workshop and highlighting earlier work undertaken in the North Atlantic region (Lowe *et al.*, 2001). Due to the limited resolution of many of the sequences spanning the Last Termination, many presentations attempted to place this period in the context of higher-resolution records from earlier periods.

Researchers from the marine realm started the presentation of records. Will Howard (University of Tasmania) presented the latest data from the South Tasman Rise that included quantified temperature reconstructions for the Last Termination. Paul Hesse (Macquarie University) presented dust records from offshore Australia and pointed out the difficulties of getting high-resolution samples from relatively low sedimentation sequences. Tim Barrows (Australian National University) presented the latest quantified reconstructions of sea surface temperature during the height of the LGM for the Australasian region, noting the greatest cooling was in the southwest and the coldest phase predated the $\delta^{18}\text{O}$ maximum by over 2000 years. Vin Morgan (Australian Antarctic Division) represented the ice community and presented the latest results from Law Dome, which through methane synchronization with the GRIP (official timescale) record demonstrated the Antarctic Cold Reversal commenced prior to the onset of GI-1 in Greenland. Numerous types of terrestrial records were presented at the meeting. Tim Barrows (Australian National University) reported the latest cosmogenic results of moraine and periglacial features in Kosciuszko and Tasmania, showing the only major advance during the Last Termination was centred on 16,800 ^{10}Be and ^{36}Cl years. John Chappell (Australian National University) presented results demonstrating that fluvial systems were considerably more active during Stage 2, due largely to more effective runoff (compared to present day). This was followed by Ed Rhodes (Australian National University) who presented the latest results from OSL dating of sand dunes from the Simpson Desert that appeared to record discrete periods of activity during the Last Termination. The palynological records obtained from lakes and bogs comprised a significant portion of the meeting. The first results were presented by Rochelle Johnston (Monash

University) who reported data from Tower Hill (Victoria) that spanned the Last Termination and showed significant changes in effective precipitation through this period. The last talk of the first day was made by Chris Turney (University of Wollongong) who presented a transect of multi-proxy results from five sequences across the southwest Pacific spanning the Last Termination.

The second day commenced with further presentations of palynological records obtained from lakes and bogs. Peter Kershaw (Monash University) highlighted the potential of a highland site in Victoria, Caledonia Fen, for reconstructing changes during the Last Termination. Geoff Hope (Australian National University) presented a high-resolution pollen record (sampled at 2 mm) from Bega Swamp that displayed sustained environmental changes during what appeared to be the Last Termination. These talks were followed by two speleothem presentations. Jian-xin Zhao (University of Queensland) presented records from China, northern Queensland and New Zealand that showed complex changes through the Last Termination, potentially reflecting contrasting North Atlantic and Antarctic influences. Kira Westaway (University of Wollongong) presented new records from Java and Flores that demonstrated broadly synchronous trends across the Last Termination. John Chappell (Australian National University) completed the presentations by reporting some of the latest work on reconstructing changes in sea level, including the commencement of global sea level rise at 19 cal ka.

The second part of the meeting involved detailed discussions about necessary protocols for the Australian INTIMATE group. A major part of the discussion was the development of a protocol for age-depth models, particularly using radiocarbon. Chronological control had formed a significant part of many of the presentations. There was widespread agreement that for the 20-10 ka period, the group should use the INTCAL98 dataset until INTCAL04 becomes available. The use of calibration programs was discussed and preference was made for either CALIB4 (<http://depts.washington.edu/qil/>) and OxCal (<http://www.rlaha.ox.ac.uk/orau/oxcal.html>) though everyone agreed they had to state which program had been used. Marine reservoir ages were noted to be of particular concern for this period. It was agreed that the marine reservoir correction available on the web (<http://radiocarbon.pa.qub.ac.uk/marine/>) should be used. There was widespread support for the reporting of all original radiocarbon ages (uncorrected) for recalibration by future workers (if necessary). It was agreed that the group would follow the recommendations (or variation of) of Lowe and Walker (2000) for the reporting of radiocarbon

ages. Protocols for the other dating methods (U-series, OSL and cosmogenic) would be drawn up for the AQUA meeting in Tasmania (December 2004).

There was some discussion that the remit of the group should be extended to cover the period 30-10 ka, though the implications of developing high-precision radiocarbon dates back to 30 ka and the extent to which meaningful comparisons could be made with the North Atlantic group were not fully explored. In the discussion, Vin Morgan agreed to transfer the Law Dome dataset onto the GRIP (INTIMATE) timescale to allow Southern Hemisphere workers in the future to directly compare their records to Antarctica and the North Atlantic group.

Comparisons of many of the datasets were made though it became clear that due to the absence of quantified palaeoclimate estimates (apart from the oceans) and the chronological uncertainties associated with the records that high-precision comparison between the datasets and further afield was not possible. However, some clear trends were noted, the most notable of which appears to have been significant warming and major ice retreat in many of the records at 15 cal ka. Much work has yet to be done but the meeting was an important first step for developing records of international importance during this crucial period.

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Towards a definitive palaeoclimate record for deglacial New Zealand

Results from the 2004 NZ-INTIMATE Workshop, Wellington, 23-24 August, 2004

Lionel Carter

A group of scientists, with a keen interest in palaeoclimatology, gathered at the GNS Rafter Laboratory to further the development of an event stratigraphy for New Zealand. The venue was symbolic. One of the classical studies of the marine environment, K. O. Emery's 1960 book, *The Sea off Southern California*, relied on radiocarbon dates provided by Athol Rafter, to help define past environmental changes on the continental shelf. Thus, even in that pioneering era, the Rafter Laboratory played a key role in palaeo-environmental analysis.

The workshop had two goals:

1. to identify and rank key palaeoclimate records from terrestrial and marine settings, for the period 30 to ~ 10 ka, and
2. to develop detailed correlations between these key records, using improved dating techniques and procedures.

The meeting was held in an air of marked collegiality, where open discussion and adherence to the workshop goals ensured success. It began with a series of presentations, outlined in Alloway (2004), that discussed palynological, glacial (including ice-core), loess and tephra records preserved in a suite of terrestrial settings ranging from Antarctic moraines to maars and lakes to limestone caves. The composite speleothem record was especially noteworthy because of the well controlled chronology and detail of the stable isotope curve, which appears to outline responses to major, climate-forcing events. A similarly robust marine record had a comparable, but not necessarily identical, event stratigraphy, which was an encouraging sign that the workshop goals were indeed achievable.

The second part of the workshop concentrated on the means of improving time control. While New

Zealand is fortunate in having many widespread late Quaternary tephras, both on and offshore, the point was made that some tephra ages should be refined with more definitive radiocarbon data, especially that from wood carbonised at the time of tephra emplacement. Radiocarbon itself provoked lively discussion, especially in relation to calibration and local reservoir ages. The consensus was for INTIMATE to use a single calibration programme, probably INTCAL04, which is scheduled for release before the end of this year.

To finalise proceedings, the last session was devoted to the selection of key onshore and offshore records for publication as an INTIMATE poster. The poster will be designed to reflect the current state of palaeoclimate knowledge in New Zealand, and to act as a catalyst for further research. It will also be a "living document" that will evolve as better environmental proxies and chronologies come to the fore. Not only will it be a document of national importance, but it will have international significance by virtue of New Zealand's strategic position in the world ocean – the landmass and surrounding submarine micro-continent forms the Pacific Gateway for the Ocean Conveyor, constricts the Antarctic Circumpolar Current, and intercepts water masses of subtropical to subpolar affinities as well as the Roaring Forties and associated weather systems. An exciting and fruitful future for NZ-INTIMATE and the palaeoclimate community is ensured.

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The Australian Archaeological Association

Annual Conference, University of New England
Armidale, NSW 12-15 December, 2004

Esmée Webb

Centre for Human Genetics
Edith Cowan University
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The topic of the Annual Conference of the Australian Archaeological Association (AAA) for 2004 was *Networks and Narratives*. This title may need some explaining for Quaternary scientists, who analyse data; whereas, like many other humanists, Australian archaeologists often strive to make the artefacts they study tell stories, or *narratives*. People operate in social frameworks, hence the artefacts they make, move, lose and trade can reflect those *networks*. Hence, most of the papers at AAA considered how archaeologists construct narratives from artefacts and use them to interpret human networks.

Monday morning began with a masterly overview of the story of human evolution by Robin Dennell (Sheffield) delivered in his inimitably deadpan and allusive style. His suggestion that narratives often mutate from explanations into obstacles should resonate with anyone who has ever tried to challenge an entrenched idea.

The rest of the day was devoted to *Artefacts, agency and narrative: the social lives of objects in archaeology and heritage*. This session, organised by Rodney Harrison (ANU), discussed how cross-disciplinary methods, principally the techniques of the Annales school of historiography, can illuminate the analysis of some classes of artefacts. The idea that artefacts can have 'social lives' is not new, but has rarely been applied in Australian archaeology. The topics addressed included: the politics of value; social aspects of artefact production and consumption; collecting and colonialism; the heritage and prestige value of artefacts.

Tuesday morning, organised by June Ross (UNE), considered the *Archaeology of Art*; as communication, a medium mediating human behaviour, transferring information and flagging or cementing social relations. Papers covered both recent research and the application of new analytical methods to the

interpretation of artwork. I found Ken Mulvaney's discussion of the depiction of now-extinct animals in Pilbara rock art, Jo McDonald's description of the artwork she has been recording in the Calvert Ranges and Jillian Ford's description of a (comparatively) non-destructive method of analysing pigments particularly relevant to my own research.

Tuesday afternoon discussed aspects of *Indigenous Archaeology*, organised by Wendy Beck (UNE), and how Archaeology is taught at those Australian universities where it can be studied, organised by Sarah Colley (Sydney). The depressing message that emerged from the latter session was that none is producing adequately trained students; partly because many departments are too small, only two or three staff, partly because it is difficult for students to gain fieldwork experience before graduating. Australian universities will have to organise course cross-accreditation, borrow / lend staff, arrange video-teaching links, etc., if they are to score the credit rating, 23 out of a possible 24, my old alma mater gained in a recent review of Archaeology Departments in the UK; but then it does have over 30 teaching staff and practical training is an essential part of all degree courses!

Undoubtedly the drawcard at this year's AAA conference was the sessions on Wednesday, focussing on the initial human colonisation of Australia, organised by Iain Davidson (UNE), and the archaeology of Flores and Sundaland, organised by Mike Morwood (UNE). The papers in these sessions are also those most likely to interest AQUA members. They will be discussed in some detail, therefore.

The timing and mode of the initial human colonisation of Australia is uniquely important because Australia was the first landmass to be settled by people which could *not* have been reached without crossing a water barrier that is

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also major biogeographical divide. Davidson has long argued that the successful colonisation of Australia was contingent on the development of language and complex social behaviour - hallmarks of anatomically modern humans (AMH), in his opinion. Conversely, Nicola Stern (La Trobe) noted that AMH emerged in Africa about 150 ka, whereas the complex technologies of the Later Stone Age did not develop until <40 ka, suggesting that African AMH also made the simpler 'Middle Palaeolithic' technologies. In which case, did they have language? Robin Derricourt (UNSW) argued that watercraft were *only* necessary to reach Australia; Europe was accessed overland around the Black Sea because the Strait of Gibraltar is 'uncrossable'. Conversely, Miguel Caparros (IPH - Paris) argued that the Strait *was* crossed - often. Jane Balme (UWA) reviewed the evidence for jewellery (beads), considered proof of complex social signalling, that apparently began about 75 ka in southern Africa. Finally, Sara Perry (Victoria, BC) rightly criticised the images used to illustrate 'popular archaeology', but was unable to offer acceptable alternatives.

Mike Morwood began the Flores sessions, which were rather disappointing, by reviewing current knowledge of the island's archaeology and palaeoanthropology. He briefly described *Homo floresiensis* (the Hobbit) from Luang Bua, which dates to c. 35-14 ka, although AMH are also present in Flores from about 50 ka. The species appear, therefore, to have coexisted, but without a firm date for the origins of *H. floresiensis* it is difficult to assess such important aspects of its evolution as the rapidity with which endemism developed, or, indeed, why. Sadly, none of the advertised Indonesian speakers was able to attend. Mark Moore (UNE) argued that the blades, often considered a sign of superior cognition, from Luang Bua were not produced deliberately. Hence, presumably, he considered *H. floresiensis* lacked the cognitive ability to make blades. Bert Roberts, Chris Turney and Kira Westaway (Wollongong) reviewed the problem of obtaining luminescence signals from Indonesian sediments, ABOX-SC developments in ^{14}C and speleothem dating, respectively. They concluded that *H. floresiensis* was found above a flowstone dated to 38 ka by U/Th and survived until 13 (cal) ka; the main period when Luang Bua would have been habitable. These were some of the best papers given at the conference, in my opinion.

The remaining papers considered Southeast Asia as a whole. Huw Barton (Leicester) reviewed the evidence for food plant use at Niah Cave, Sarawak, which began about 45 ka. Most are toxic and require considerable pretreatment. Robin Dennell and Michael Westaway (NPWS) discussed the *Homo erectus* remains from Java and came, unsurprisingly, to very different conclusions! David Bulbeck (ANU) reviewed the evidence for AMH in eastern Indonesia and concluded that *H. floresiensis* is totally anomalous, but does resemble Andaman Islanders. Finally, Sue O'Connor (ANU) argued that the 'package' of behaviours called Neolithic in Southeast Asia needs to be rethought - much as the Eurasian Neolithic was 'unpacked' 20 years' ago; while Peter Veth (AIATSIS) concluded that AMH was not subject to biogeographic controls - Southeast Asian archaeological evidence was so diverse by 60 ka.

The conference was preceded by a postgraduate workshop intended to bring attendees up to date on the latest developments in Australian archaeological practice, dating techniques and employment possibilities. While a worthy concept, this workshop was poorly structured; insufficient time was allowed for questions from the floor, which meant that, in effect, the attendees listened to a series of lectures. This session would have worked better had the talks been much briefer and the discussion time greatly extended.

The papers given at AAA conferences are usually published during the subsequent year, while the abstracts may yet be available on the website (www.australianarchaeologicalassociation.com.au) - surely one of the longest web addresses ever. If not, they might be available by contacting session organisers.

The absence of archaeologists at Cradle Mountain was, rightly, deplored; although some of the topics discussed were undoubtedly irrelevant to the research concerns of most Australian archaeologists. If AQUA wants to encourage archaeologists to attend its conferences, something I feel would benefit both associations, it should try to schedule its 2006 meeting to run back-to-back with AAA, always held in December, at a neighbouring locale. Then, people who come from far afield might be able to fit both meetings into one airfare.

IGC-UK 2004 One Earth – Many Worlds

30th Congress of the International Geographical Union, Glasgow, August 2004

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Scotland is a remarkable country; it was an ideal location for the 30th Congress of the International Geographical Union, which was held from 15–20 August 2004 at the Scottish Exhibition and Conference Centre on the banks of the River Clyde, Glasgow. The city of Glasgow is situated on drumlins formed during Quaternary glaciation and the surrounding countryside abounds in awesome glacial landforms. A particular highlight of the Congress was a field trip led by Doug Benn and John Gordon to Glen Coe, Glen Roy and Loch Lomond to explore some of the most important glacial geomorphology sites in Scotland.

The Congress involved associated meetings of the Royal Geographical Society (with The Institute of British Geographers), the International Cartographic Association and British Cartographic Society, and the Association of Geographic Information, as well as a Joint International Geomorphology Conference on Geomorphology and Sustainability. Presentations during the opening ceremony focused on the relevance of geography to a diversity of issues, the importance of communicating to the public that the discipline of geography matters, and the need for the discipline to, in the words of Scotland's polar hero William Speirs Bruce, "serve humanity by adding another link to the golden chain of science".

Several hundred seminars and posters were presented over the week, along with interesting talks by plenary speakers such as Andrew Goudie. Professor Goudie's presentation explored the nature of dust storms, their environmental consequences, their global and local sources and trajectories, and their changing frequency. He noted that closed basins in very dry regions such as Chad's Bodele Depression are major dust sources. In some of these locations dust storms are becoming more frequent because of anthropogenic pressures

on land surfaces (eg 4WD vehicles) and changes in precipitation and wind characteristics.

My own seminar, which was presented in the Advances in Karst Geomorphology and Hydrology session, concerned fluvial tufas of monsoonal Australia and focussed on the value of tufas as a source of information about palaeomonsoon activity. Other karst presentations that may be of interest to readers of *Quaternary Australasia* included those of Ian Fairchild, who discussed the preservation of climatic indicators in karst hydrogeochemical signals, and Andy Baker's investigation of the geographical locations of annually and sub-annually laminated stalagmites, and their likely lamina width.

In other sessions, Xiaoping Yang gave an intriguing account of the ion chemistry of permanent lakes in the Badain Jaran Desert of Mongolia and reported that there is a positive correlation between the ages of the lakes and their total dissolved solids. During the early and middle Holocene, inter-dune hollows contained large lakes with low salinities. Palaeohydrology and TL and radiocarbon ages show that decreased water availability and enrichment of ions in the lakes originated from climatic desiccation during the late Holocene. Allan Werritty discussed research in a far more humid part of the world, Scotland's River Tay, where a meander cutoff has been infilling with flood deposits since around 1763. These sediments have been cored, dated using ^{137}Cs and ^{210}Pb methods, and the timing of flood events independently corroborated by flood marks on a bridge in Perth, 15 km downstream. The resulting flood record allows improved estimates of flood risk at Perth.

Overall, I found the IGC very interesting and it was inspiring to hear about the diverse research questions being investigated throughout the world. The 31st Congress will be held in 2008 in Tunisia, which appears to be another fascinating place to explore.

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FORTHCOMING CONFERENCES & MEETINGS

10th Conference on Australasian Vertebrate Evolution Palaeontology and Systematics (CAVEPS) and Quaternary Extinctions Symposium

Naracoorte, South Australia, Australia

29 March - 2 April 2005

<http://www.environment.sa.gov.au/parks/naracoorte/events.html>

TENISON-WOODS Cave palaeontology session
The Naracoorte Caves National Park is a World Heritage listed fossil site, so it is appropriate that a session deals specifically with cave deposits. The final day of general sessions (Thursday 31st March) will be a special session focusing on cave palaeontology. It will explore the question - "What contribution have cave sites made to our understanding of vertebrate history". Convening this session will be Professor Ernest Lundelius, Dr Mike Augee, Dr Liz Reed and Mr Steven Bourne.

Contributions covering all aspects of cave palaeontology (eg. faunas, geology, site studies, taphonomy, dating) are invited.

QUATERNARY EXTINCTIONS SYMPOSIUM

A two day thematic symposium exploring Quaternary extinctions will follow the general and cave sessions. Papers are invited for this symposium which will cover a wide range of relevant topics including: dating and extinction chronologies, causes and patterns of extinction, significant site studies, background and review studies, island extinctions and modern extinctions. Keynote speakers for the Extinction symposium include Professor Anthony Barnosky from the University of California at Berkeley and Professor Alan Cooper from the University of Oxford.

Papers are invited for the Quaternary Extinctions symposium. This symposium will cover a wide range of relevant topics including: dating and extinction chronologies, causes and patterns of extinction, significant site studies, background and reviews, island extinctions, modern extinctions.

More information:

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Australasian Archaeometry Conference 2005

Department of Archaeology and Natural History

Coombs Building

Australian National University

Canberra, Australia

12-15 December 2005

http://car.anu.edu.au/archaeometry_conference.html

The 2005 Australasian Archaeometry Conference will be held at the ANU, Canberra, hosted by the Department of Archaeology and Natural History, RSPAS, and the Centre for Archaeological Research. The organising committee invite sessions covering all aspects of scientific applications (biological, physical and chemical sciences) in archaeology. Session proposals (title and max. 200 word abstract) are now being considered and should reach the committee by February 11th 2005. Proposals for technical workshops are also being sought and should include details of technical/space requirements. The organising committee will consider theoretical and interpretative sessions as well as those discussing archaeometrical techniques. Sessions and papers usually focus on Australasia and the broader Asia-Pacific region, but sessions/papers by researchers working in other geographical areas will also be considered, especially if they have some relevance to work within the region (e.g. help to build up technical competency etc).

Further information:

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AUSTRALIA

'Extremes: Survival in the Great Deserts of the Southern Hemisphere'

is a comparative look at the archaeology, rock art and environmental history of the major southern hemisphere deserts (including the Namib, Kalahari, Australian arid zone, and the Atacama).

It shows at the National Museum of Australia, in Canberra until late August.

For more information see www.nma.gov.au

There will be a further EPICA (European Project for Ice Coring in Antarctica)

session at the EGU assembly, following those held in the two previous years. However this time we have specifically extended the scope to cover data from other media that are being compared with EPICA ice core records and similar time periods. We are therefore pleased to invite abstracts to be considered for both oral and poster presentation.

The meeting will be held 24-29 April 2005 in Vienna, Austria. Our EPICA session is number CL29, European Project for Ice Coring in Antarctica (EPICA and EPICA-MIS). The convenors are Dominique Raynaud, Eric Wolff and Hubertus Fischer.

Meeting website is:

<http://www.copernicus.org/EGU/ga/egu05/index.htm>

The Fluvial System – past and present dynamics and controls

International Conference 16-22 May, 2005 at the Department of Geography of the University of Bonn Germany.

<http://www.giub.uni-bonn.de/fluvialsystem2005/>

A central session "Past hydrological events related to understanding global change" will open the conference, additional topics are:

- * development of refined global and regional chronologies
- * fluvial system modelling
- * hydraulics of open channel flow
- * implications of long term research in relation to forecasts and prognoses for the future
- * interpreting anthropogenic influences
- * new techniques and methods of investigation
- * past hydrological and catastrophic events

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2nd Southern Deserts Conference

Human-Environment Interactions In Southern Hemisphere Deserts: Past, Present, And Future.
Arica, Chile 10-14 October 2005

This looks like another fascinating desert conference with the opportunity to see a good range of landscapes in the Atacama Desert. A pdf with further conference details is available on request from m.smith@nma.gov.au. Any other queries to Arica.deserts2005@uta.cl or csantoro@uta.cl or clatorre@bio.puc.cl.

The Southern African Society for Quaternary Research (SASQUA)

will hold its XVI Conference, 30 March - 3 April 2005, the University of the Free State in Bloemfontein, South Africa.

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IGCP Project No. 500: Westerlies and Monsoons:

Impacts of Climate Change and Variability on Dryland Environments, Hydrogeology and People

This project follows and builds on previous IGCP Projects 349 (Desert Margins and Palaeomonsoons) and 413 (Understanding Future Dryland Changes from Past Dynamics), 1998-2003.

<http://www.shef.ac.uk/~igcp413>

Project Leader: D.Thomas (United Kingdom)

Countries involved: Australia, Botswana, Canada, Chile, China, Finland, Germany, India, Iran, South Africa, Switzerland, United Kingdom, United States
Duration: 2004-2008

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International Workshop on Sub-aerially Exposed Continental Shelves Since the Middle Pleistocene Climatic Transition

9-13 May 2005

The first circular of the this international workshop is available by clicking conferences on www.hku.hk/earthsci/other/des_fram.htm,



QUATERNARY AUSTRALASIA

Quaternary Australasia publishes news, commentary, notices of upcoming events, travel, conference and research reports, thesis abstracts and peer-reviewed research papers of interest to the community. Images of mystery fossils and amusing occupational health and safety breaches also welcome. Non-refereed material for QA 23(1) should reach the editor by 1 July 2005. Please ensure that citations, in both refereed and non-refereed manuscripts, are formatted to conform to *Quaternary Australasia* style. An Endnote 7.0 for Mac style file is available on request.

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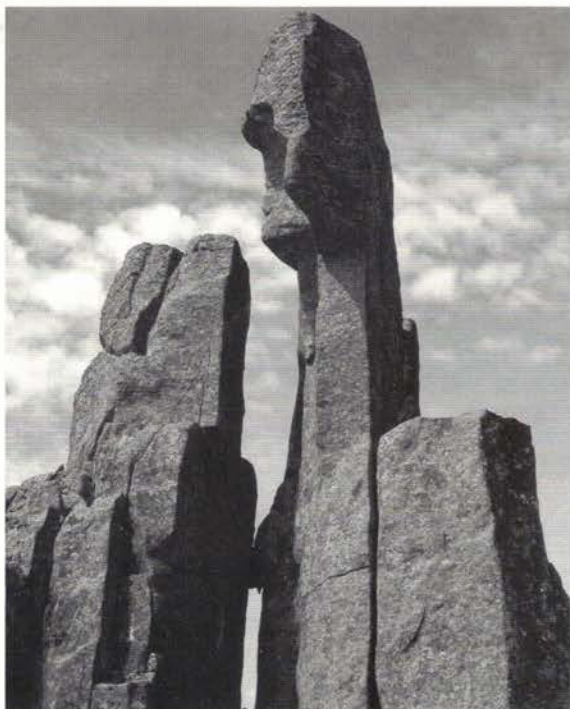


Photo: G. Jordan

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