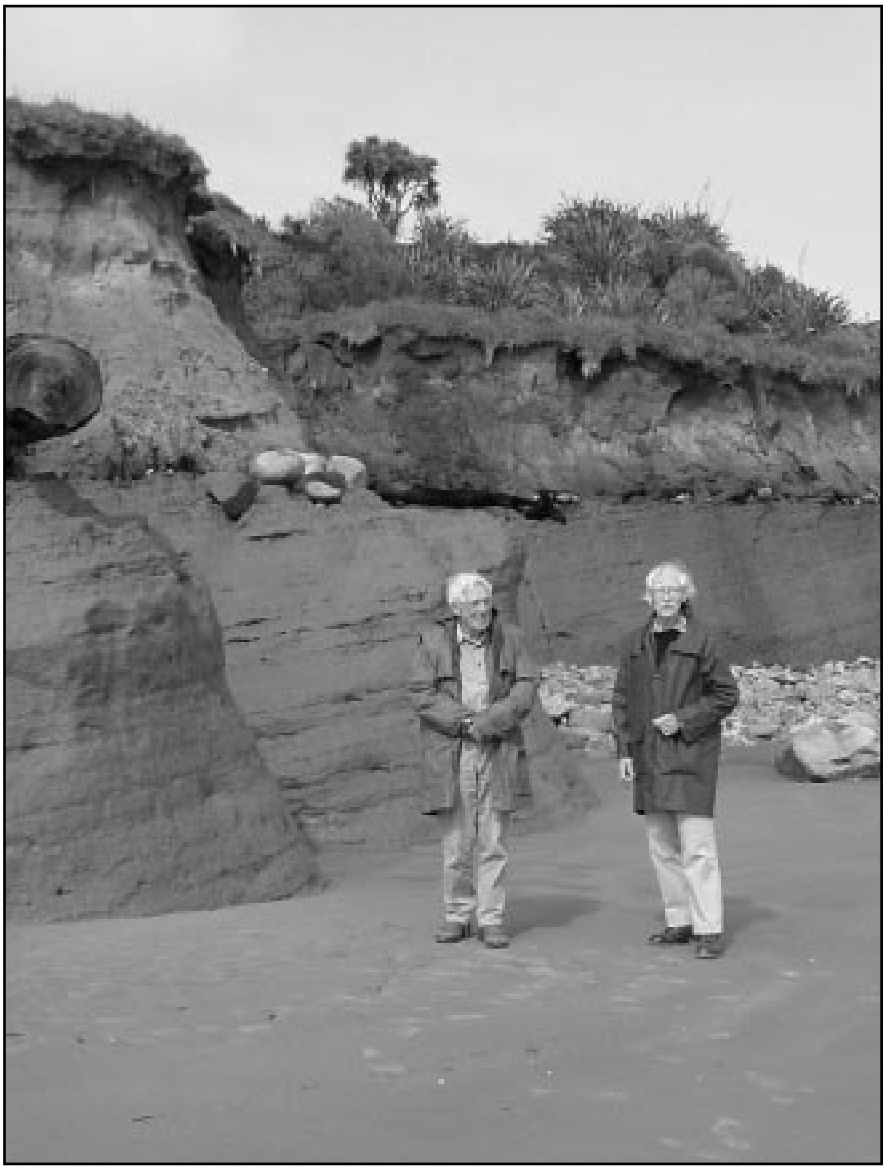
QUATERNARY AUSTRALASIA



VOLUME 21 NO 1   JULY 2003

CONTENTS

All Research Papers published in *Quaternary Australasia* have been peer reviewed.

Cover illustration: Neville Moar (left) and Pat Suggate near Cape Foulwind, looking out into the wild Tasman Sea. Behind them the 8 m high beach cliff exposes a post-glacial shore platform formed in Miocene mudstones, overlain by boulders, beach sands, giant logs (c. 6000 BP) and sandy coverbeds. See Peter Almond's report from the AQUA 2003 North Westland Coast field trip, page 10.

EDITORIAL

This issue of *Quaternary Australasia* is dominated by material — in particular, field trip reports with photos, and abstracts from students who won either travel prizes or presentation awards — associated with the Australasian Quaternary Association biennial conference in Westport, New Zealand, 3–7 February of this year. The conference, held for the first time outside of Australia, not surprisingly attracted a large contingent of New Zealanders (44 registrants), somewhat more than the number of Australians (34 registrants), although these figures refer to the location of members' home institutions, and take no account of a few Quaternarists who have hopped one way or the other across the Tasman. My impression from the meeting, my first visit to Aotearoa, was that study of and interest in the Quaternary on the two landmasses has perhaps been more isolated and divergent than is desirable, given the (partly) shared environmental histories, and close geographic and cultural proximity of the two countries. Although the first letter of our acronym inclusively (but perhaps optimistically) stands for 'Australasia', I must admit that prior to the publicity for the Westport conference, I had never even heard of Friends of the Pleistocene, effectively New Zealand's Quaternary Association, and I'm certain I overheard at Westport a New Zealand Quaternary scientist mention that their involvement in the conference represented the first time they had ever heard of AQUA. It may therefore prove fruitful for closer communication that one legacy of the conference was the election of Brent Alloway (IGNS, Taupo) to the newly created post of AQUA Vice-President, while Maureen Marra (*ex*-Vic. Uni. Wellington) accepted the responsibility of acting as New Zealand subeditor for *QA*. Two long serving office bearers retired: Christine Kenyon passed on the Treasurer's key to Janelle Stevenson, while Kate Harle passed the Editor's pen to me. Simon Haberle remains AQUA's President.

This issue contains abstracts from six students — Iona Flett, Joseph Hägg, Janece McDonald, Annabel Morris, Craig Sloss and myself — that won AQUA travel prizes and/or presentation awards, Patricia Fanning's PhD thesis abstract, and a report by Helen McGregor on the NCCR Climate International Summer School, during September 2002, in Grindelwald, Switzerland. Vice-President Brent Alloway introduces himself to the Australasian Quaternary community and reports on the post-conference AQUA field trip, David Kennedy details the pre-conference trip, and Peter Almond carries us through the Quaternary geology of Westland with the benefit of more than a century of combined experience of the Moar and Suggate research partnership. Paul Hesse comments on the location and significance of the silt/sand boundary, and we have one research paper by Scott Mooney and Manu Black describing an approach to quantification of macro-charcoal in sediments by digital image analysis. The new look of this issue of QA is due to AQUA handing on its production and printing responsibilities to Pandanus Books of the Research School of Pacific and Asian Studies and The Australian National University.

Cordially,

Kale Sniderman
Editor

PRESIDENT'S PEN

Trying to gauge the future directions of Quaternary studies in Australia is not an easy thing. Using our mantra of 'looking at the past to understand the future' one way may be to determine what it is that turns us, and perhaps more importantly *them* (the international community), on about the Quaternary in our region. If you believe that the journals of *Science* and *Nature* reflect this sentiment then what does the content of these journals tell us? Doing a quick search using 'Quaternary' and 'Australia' in both journals' web pages for the last five years produced 13 results and I would contend that the subjects covered reveals as much about the way the region is perceived as it does about the direction of the research. Seven papers deal with the antiquity of human occupation of Australia and, of the other six papers, five deal with the timing of change and nature of our fickle climate during the time of human occupation. In summary this seems to reflect an overwhelming obsession with the age of things. While there are clear reasons why this is so (i.e. development of new dating techniques opening up a world previously closed to investigation) there remains the question 'Is there nothing more interesting to tell'? In a recent article by Bob Beale in the *Bulletin* ('The Real First Fleet', June 24, 2003) the same sentiment is expressed by Australian archaeologists lamenting the loss of the art of telling a good story in favour of simply finding the oldest and the biggest. It remains to be seen if this trend continues, or indeed is allowed to continue through ARC funding for the foreseeable future. While there is a necessary reliance on good dating control, the answers to the more interesting questions of *why* and *how* things happened will rely on much more multidisciplinary approaches to constructing the past. Given the rise in popularity of 'natural history' books on shelves in our local newsagencies, it would appear that there is a growing thirst for reading and learning about the past. The potential is clearly there to develop a strong public awareness of the nature of the *Australian Quaternary* and it is hoped that researchers and teachers of the subject will capitalise on this.

Simon

Papers appearing in *Science* and *Nature* over the last 5 years:

Jim Bowler et al. 2003. New ages for human occupation and climatic change at Lake Mungo, Australia. *Nature*, 421: 837–40.

Julia Cole 2003. Dishing the dirt on coral reefs. *Nature*, 421: 705–6.

Malcolm McCulloch et al. 2003. Coral record of increased sediment flux to the inner Great Barrier Reef since European settlement. *Nature*, 421: 727–30.

Erica Hendy et al. 2002. Abrupt decrease in tropical Pacific sea surface salinity at end of Little Ice Age. *Science*, 295: 1511–4.

Jared Diamond 2001. Australia's last giants. *Nature*, 411: 755–7.

Jonathan Nott and Matthew Hayne 2001. High frequency of 'super-cyclones' along the Great Barrier Reef over the past 5,000 years. *Nature*, 413: 508–12.

Richard Roberts et al. 2001. New ages for the last Australian megafauna: continent-wide extinction about 46,000 years ago. *Science*, 292: 1888–92.

Yusuke Yokoyama et al. 2000. Timing of the Last Glacial Maximum from observed sea-level minima to brackish conditions and then back to shallow marginal marine. *Nature*, 406: 713–6.

Beverly Johnson et al. 1999. 65,000 years of vegetation change in Central Australia and the Australian Summer Monsoon. *Science*, 284: 1150–2.

Gifford Miller et al. 1999. Pleistocene extinction of *Genyornis newtoni*: human impact on Australian megafauna. *Science*, 283: 205–8.

Michael Gagan et al. 1998. Temperature and surface-ocean water balance of the Mid-Holocene tropical western Pacific. *Science*, 279:1014–8.

Richard Roberts et al. 1998. Optical and radiocarbon dating at Jinmium rock shelter in northern Australia. *Nature*, 393: 358–62.

Richard Roberts et al. 1997. Luminescence dating of rock art and past environments using mud-wasp nests in northern Australia. *Nature*, 387: 696–9.

Brent Alloway – New AQUA Vice-President

Greetings! My name is Brent Alloway and I have recently been elected to the position of Vice-President of AQUA. I am a Quaternary Earth Scientist with a broad knowledge and experience of New Zealand Quaternary paleoenvironments. I really like to describe myself as a jack-of-all-trades and a master of nothing. However, I do have some expertise in determining eruptive histories of andesitic volcanoes, characterising and mapping weathered volcanic deposits and soils, hazard mapping, eruption preparedness and contingency planning.

I am currently employed as a Senior Scientist with the Institute of Geological and Nuclear Sciences — a NZ Crown Research Institute, and was formerly the Chief Volcanologist and Manager of the Volcanoes Section. I am based at the Wairakei Research Centre which is pleasantly located at Taupo in the central North Island. I am presently Leader of the Quaternary Objective of the Global Change through Time Programme (GCT). I manage and participate in a multidisciplinary research programme involving 21 scientific staff.

I am a former senior lecturer at Auckland University and a regular contributor to earth science educational outreach. I've been working on volcanic stratigraphy, landforms and associated hazards in the Taranaki Region for more than two decades and work very closely with the regional government there. I have also done research/consultancy in a variety of volcanic environments in Indonesia, Philippines, SW Pacific (Fiji, Samoa and Vanuatu), as well as in North (Idaho, Alaska, Yukon), Central (Costa Rica) and South (Colombia) America. I am fully committed to promoting better communication and collaboration between various Quaternary researchers in New Zealand and indeed, across the Tasman. It is my intent to use AQUA as the appropriate and effective vehicle to achieve this goal. I am also fully committed to realising aspirations of the Australian Quaternary community to host the XVII INQUA meeting in 2007.

There is much to do in terms of elevating the profile of AQUA to the greater Quaternary research community here in New Zealand and strengthening research linkages. I certainly look forward to the task at hand. Best wishes to you all.

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The Big(ness) Question

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Do we speak the same language when we use even ordinary scientific terms? I recently discovered that my co-author and I had been talking at cross-purposes over 'silts' and 'sands' in the samples we were describing in our paper. Not long after I was explaining to some second year students the usage of another geomorphic term and the multiplicity of definitions, when one responded 'how unusual for scientists to disagree!' Fair enough. From her point of view it's not an ongoing dialogue, just a failure to get our act together.

Hence the question I posted to AQUAlist: what particle size do Australasian Quaternarists use as the boundary between silt and sand?

The Vote (who actually uses what)

62.5* microns	22 people	(4 phi; *reported as 62, 62.5, 63, 64)
50 microns		1 person?
32 microns	(5 phi; 31.25 microns)	1 person
20 microns		4 people

Overwhelmingly (79%) the respondents use the 62.5µm boundary (or an approximation of it) of the Udden-Wentworth scheme (Udden, 1914. *Bull. Geol. Soc. Am.*, 25: 655; Wentworth, 1922. *J. Geol.*, 30: 377).

The next largest group use the 20 µm boundary of the International Society of Soil Science, also used in Australian soil science (See Marshall, T.J., *Aust. J. Soil Res.*, 2003. 41: 245–9, and references therein, including Prescott, Taylor and Marshall T.J., 1934. Marshall's sixty-nine year span of publishing (at least) must be close to a record and certainly gives a legitimate historical perspective.)

Other variations mentioned (but not necessarily used by the reporter)

- 50 microns (*World Soils Book*, Bridges, 1978, University of Cambridge Press)
- 16 microns ('The bible': *Bodem en bemesting*, Commission for soils 1939), later revised to 50 microns (i.e. Dutch usage.)
- 60 microns (in NZ soil science since 1991. Previously the old 'international' boundary of 20 microns was used)

Justifications (theoretical)

- 62.5 microns. 'Because if you also use the phi scale (where 0 phi=1mm) for descriptive purposes, 62.5 occurs at –4.0 phi and is the very fine sand/silt boundary, –3 phi the fine sand /very fine sand boundary etc. None of the other values you indicated fit a whole phi unit.' (Roger McLean)
- 'The 63 micron boundary is part of a geometrical progression that makes some sense numerically.' (Stephen Gale)
- '20 microns: the International system based on Atterberg limits being the log scale 2.0mm, 0.2mm, .02mm and .002mm. Has the logic of the log scale size variation.' (Eric Colhoun)

What theory tells us

You can justify your choice, whatever it is. There are adherents to a log base 2 system (the majority) and adherents to a log base 10 system (the minority), although both of these achieve the same end; the principal divisions are equally spaced on a log scale. Finer divisions of the phi scale are also log-based, however that is not the case for the ISSS system.

Justifications (practical)

- 'So far as I'm aware, 20 and 50 micron sieve meshes aren't easily available, though the 74.3 micron mesh is pretty close to the coggies' 75 micron boundary.' (Stephen Gale)
- 'I don't use 63 microns, wouldn't use 75 microns, haven't actually used 50 microns although my US/Canadian reference card puts 62 microns as bottom of very fine sand and guess it follows that silts starts at the next sieve-step down — in quarter-phi steps this would be 52 microns. However and inconsistently I habitually use 32 microns as the top of the silt range!!!' (John Chappell) (this response has not been edited except to remove the word bugger)
- 'The Australian Soil and Land Survey Handbook (McDonald et al. 2nd edition, 1990) attempts to provide some sort of standard for (at least soils) field work in Australia. It suggests using the International System of particle size scale (2 / 20 / 200 / 2000 micron divisions). I use it for the sake of conforming, but I'd use the 63 micron boundary if sieving was the only form of particle size analysis available.' (Meredith Orr)
- 'Geoscience Australia have a very handy little class card, with ruler, that puts the cut-off between silt and sand at <62 microns (i.e. silt is classed between 3.9 and 62 microns).' (Kate Harle)
- 'The practical application of this (the Udden and Wentworth classification) is that in working in the Quaternary coastal environments of northern NSW and southeast Queensland, particularly sand dune systems up to 98% of my samples fall within the sand fraction as defined as >63 micron.' (Maria Cotter)

Although an adherence to sieve sizes is practical, Meredith is right that this hasn't been a limitation for quite some time. Stephen may also be interested to know that 20 and 50 micron mesh sieves are among British Standard sizes (Goudie et al. 1981, *Geomorphological Techniques*). A further practical point is whether anyone would want to sieve at 20 or 50 microns. In my experience 63 microns is bad enough, with the grains clogging the sieve and being difficult to shift. The difficulty of sieving in this size fraction is one manifestation of a real difference in behaviour of materials with size; a point made by Maria with a real world example. This question is not necessarily a semantic one if we return to the question 'is sand different to silt?'

More justifications (the Nuremberg defence)

(all identities have been concealed to protect professional reputations, but the number of xs is a hint)

- 'I have always used 63 microns as the sand/silt boundary — that's the boundary that has always been taught in Quaternary science, coastal geomorphology and sedimentology pracs at xxxxxx Uni.'
- '63 microns … from xxxxxxxxx Uni PSA that we were taught when we were kids, wet sieving to separate sands from silts and clays!'
- '63 micron — is what I use (but not sure why?).' xxxxx
- 'We have always used 63 microns.' xxxxxx varsity.
- '(63 microns) BUT I use this because that is what I was taught and never really considered it an issue.' xxxxxxxxxx Uni

Given this unquestioning use of the 63 micron cut-off by many respondents, it's interesting that the four users of the 20 micron cut-off share no (known) institutional history. Even stranger, there are several instances (including me) of students and supervisors obliviously using different boundaries.

Disciplinary (national?) differences

Although most respondents used the 62.5 micron cut-off, respondents who use the 20 micron cut-off cover a diverse range of fields and there is no clear pattern of disciplinary bias. In the wider literature there are clearly some disciplinary differences …

- 20 microns, Australian soil science
- 50 microns, American and Dutch soil science
- 60 microns, NZ soil science (David Lowe) and British?
- 63 microns, boundary between medium and fine ash in Volcanology (David Lowe)
- 63 microns, tsunami and storm surge literature (Adam Switzer)
- 63 microns, sea sediment samples (Leanne Armand, Antarctic CRC)

Brent Alloway was quick to reach for his *Glossary of Geology* (Bates and Jackson, 3rd Edition) which gives two definitions for silt — one for sediment and another for soil.

silt (sed) — a rock fragment or detrital particle smaller than a very fine sand grain and larger than a coarse clay, having a diameter in the range of 1/256 to 1/16 mm (4–62 microns, or 8 to 4 phi units) *silt* (soil) — a rock or mineral particle in the soil having a diameter in the range of 0.002–0.05 mm. The diameter range recognised by the International Society of Soil Science is 0.002–0.02 mm.

This would be fine, except that there are several definitions in use within soil science globally. Eric Colhoun, in support of the 20 micron (Atterberg) scale says, 'I am aware of the others but I think this is the most widely used in Geomorph and Geol circles.' Sorry Eric, but at least in this survey you're in the minority.

A New Controversy?

Kate Harle's response hints at another issue I had never considered: what is the silt/clay boundary? Stephen Gale notes 'An even more widespread gulf exists in the location of the silt/clay boundary (there's a comment on this in Gale and Hoare's *Quaternary Sediments* p. 60)'. Apparently Geoscience Australia use the 3.9 micron (8 phi) boundary as did Folk (1968, *Petrology of Sedimentary Rocks*), who in most things is a level headed guide to particle sizing. I have always used 2 microns (9 phi) which I have always regarded as 'standard' (the Nuremberg defence dressed up). Brent Alloway has highlighted the disciplinary difference in his response with a 4 micron boundary for sediment and a 2 micron boundary for soil.

What was the question again?

Although I was originally keen to see only what definition people used, it has become interesting now to work out what we think we are defining. Nearly everyone has replied in a way that implies that the boundaries are arbitrary on a natural continuum; that we use one or the other simply for mathematical or processing ease.

But is there a physical basis for the boundary? Is silt a different material from sand? The fact that we have different words implies some fundamental difference. Bagnold (1954, *Physics of Blown Sand and Desert Dunes*, 2nd edition) is usually good for some guidance but turned out to be a great example of the dilemma. Early on Bagnold defines sand as particles between 1mm and 20μm, but later gives a functional description of sand as 'solid non-cohesive particles which self-accumulate', in ripples and dunes, for example. Later he describes many aspects of particle behaviour in both wind and air and it's obvious there is not a single sharp boundary. However, two things are clear: 1) the log relationship is real and universal, 2) there is an important change in behaviour somewhere in the range 50–200μm (related to entrainment or deposition in air or water) but it would be hard to argue between either 50, 60 or 62.5μm except as a matter of convenience. However, there is no evidence of any change of behaviour around 20μm.

Who cares? Colin Pain has entered the debate with a bucket of cold water over it all, suggesting that 'simple is best' (to paraphrase Robert Ehrlich, 1983. *J. Sed. Pet.* 53). But this forceful denunciation is of misusing misleading statistics of particle size distributions and the long, so far fruitless, search to find some statistic which separates sediments according to the depositional environment. I couldn't agree more, but it's a different question to whether we even agree on the terminology we use. The last word goes to Matthew Fischer who says it does matter and provided 43 pages of equations to prove it (Weltje, 1992. *Earth Science Reviews*, 57: 211).

Final words of wisdom

'If you can see the grains then it's probably sand. If it is "grainless" by eye but gritty between the teeth then its silt and if it's smooth its clay.' (Mark Taylor)

Contributors

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Craig Sloss, Wollongong University
Brent Alloway, GNS-NZ
Stephen Gale, Sydney University
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Meredith Orr, Monash University
Martin Williams, Adelaide University
Gary Brierley, Macquarie University
Matthew Fischer, Sydney University
Geoff Humphreys, Macquarie University
Damian Gore, Macquarie University
Grant McTainsh, Griffith University
Colin Pain, CRC LEME

Australasian Quaternary Association field trip report:

Wanderings from Wellington to Westport

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The pre-conference trip began on a clear sunny day with a good dose of Wellington wind when 19 avid Quaternarists set forth on a voyage of discovery of the New Zealand landscape. The trip contrasted a wide range of Quaternary landscapes shaped by highly active tectonics with a large overprint of glacial sediments. The trip started at the top of the Wellington Cable Car with a great view over the main CBD. On the first day we travelled round the Wellington region investigating many Holocene landforms that have been offset by recent fault movement, such as the displaced fluvial terraces at Harcourt Park. The Wellington Fault has offset these terraces, by up to 35 m in places. These movements are most probably in the form of instantaneous co-sesimic events in excess of magnitude 8. The trip also paused on some of the hills round the region and admired many of the raised marine terraces that have formed around the harbour. A good feed of greasy fish and chips was enjoyed by all and while eating them everyone appreciated why the local Super 12 Rugby team is know as the Hurricanes. The trip then boarded the ferry to cross Cooks Strait and through the subsiding Marlborough Sounds to Picton. The sounds are the subsiding extension of the Wanganui Basin to the north west of Wellington. The uplifting northern part of this basin is characterised by a series of uplifted marine sediments which preserve a good proportion of the Quaternary sea-level oscillations. From Picton the trip travelled to Blenheim where we overnighted and sampled the sights and sounds of the town. A longish walk by a few people found the best place to eat was a take-away next to the camp … sweet as, bro! (field trip humour).

The second day of the trip travelled from Blenheim to Kaikoura. We investigated a suit of aggradational fluvio-glacial terraces in the Awatere Valley. These terraces have formed primarily during the last few glacial periods and have cover beds of loess many 10s of metres thick. Smaller terracettes are also evident related to movement along the Awatere Fault. A small diversion was made to the Vavasour Winery for supplies (a mutiny was on the cards without at least one winery stop in the Blenheim area!) where some very nice Sauvignon Blancs were acquired and the occasional Pinot Noir. From there we travelled along the coast stopping in places to look at a few gravel beaches (both the pure-gravel and mixed sand and gravel types) before reaching Kaikoura in the evening. A trip was planned out to the shore platforms on the peninsula. Unfortunately, although the weather gods were very kind, the tidal ones were against us and we found the platforms completely inundated. After deciding that $70 was a bit steep for a 1/2 lobster pulled off the rocks a few hundred metres away, the trip decided to overload a small pizza place and then eat on the beach.

The third day saw us travel coast to coast via the Lewis Pass. A lovely sea fog obscured the view of the mountains at Kaikoura but this cleared as we followed the inland route along the Hope Fault. We then travelled through the Hamner Basin, stopping in Hamner for lunch, though not enough time for hot-pool swimming. We then proceeded up into the mountains. The road from Hamner to the Lewis Pass is characterised by some very large aggradational terraces which the road winds through. These are gradually lost as the road heads higher as the valleys become predominantly erosional. A short stop was made at the Tarn lake at the top of the Pass where the trip was met by a cloudless sky and 20+ temperatures (a bit different to the fog and 5 deg I had before Christmas when recce-ing the trip). The trip then proceeded down to the West Coast through the glaciated valleys and along the Alpine fault. We stopped at Evison's Wall just down from Mauria Springs. This wall was constructed in the 1960s on a series of terraces (the oldest being 14ka) that are offset across the Alpine fault, in an attempt to detect if there was any creep along the fault (none has been recorded). The trip then proceeded through Reefton where the valleys widen out and a series of fluvio-glacial terraces dating from OI Stage 8 to Stage 2 are preserved, and into the Buller Gorge before arriving at the conference venue in Westport.

AQUA and New Zealand Friends of the Pleistocene Westport Conference mid-conference field trip report

Quaternary Geology of the North Westland Coast

Peter Almond

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The AQUA and Friends of the Pleistocene mid-conference field trip on Thursday 6 February 2003, took advantage of 112 years of combined experience held by Pat Suggate and Neville Moar of Westland's Quaternary geology. Independently, they both ventured into Westland in 1947; Pat as a geologist with Geological Survey under the mentorship of Harold Wellman, and Neville as a junior botanist and palynologist based in Canterbury with Botany Division. Pat's first monograph on the glacial geology of Westland, co-authored with Max Gage and published in 1958 (Gage and Suggate, 1958), was the precursor to a very important piece of work in the New Zealand Quaternary geology literature. 'Late Pleistocene Geology of the northern part of the South Island' (Suggate, 1965) established the stratigraphic framework for New Zealand Quaternary studies through to the late 1980s when Pat published a revision (Suggate, 1990). Neville's early botanical studies in Westland evolved into an analysis of the paleobotanical history of the post-glacial in Westland and Canterbury. The Moar and Suggate partnership was struck up in 1964 when Pat offered Neville the prospect of some interesting post-glacial sites in Westland (Moar 1971, 1973). With the post-glacial conquered the duo moved back in time using pollen analysis to test hypotheses based on Pat's stratigraphic framework and to learn more about New Zealand's botanical and ecological history. The sites visited on the mid-conference field trip span a period of field work from 1958 to the present day and drew from a number of publications, the most recent being a major review paper published in 1996 (Moar and Suggate, 1996).

The field trip began in Westport and went west along the coast to Cape Foulwind, then south east via Wilsons Lead Road across broad raised coastal terraces to State Highway 6. The route then followed State Highway 6 south along the spectacular coastline of headlands, long gravel beaches and raised coastal terraces cut into the steep front range of the Paparoas.

Stop 1 Larsens Road Post Glacial shore platform and coverbeds

Larsen's Road ends above the beach mid-way between Westport and Cape Foulwind, looking out into the wild Tasman Sea. The 8 m high beach cliff exposes a post-glacial shore platform formed in Miocene mudstones, overlain by boulders, beach sands, giant logs and sandy coverbeds. Material from the woody layer was radiocarbon dated at 6,330 ± 65 years BP (Nathan, 1975). The modern beach, about 4 m lower than the relict shore platform, was exposed beautifully at low tide when we visited. It provided an exemplary analogue for the development of the Pleistocene marine benches that characterise the uplifting North Westland coastline. The quantitatively minded were surveying levels and calculating an uplift rate for future curly questions.

Stop 2 Cape Foulwind

The Cape Foulwind section is again exposed in a beach cliff cut into a high level terrace. The 30 m high section shows 10 m of sandy coverbeds (Waites Formation) over a thin peat sitting on boulders that rest on a shore platform cut in Tertiary siltstone. Neville and Pat first visited the site for sampling in 1969. The results were published in a 1979 paper along with pollen analyses from eight other local sites (Moar and Suggate, 1979), including the site discussed at Stop 3, 'The Hill', and Martins Quarry discussed below. Pollen from the peat above the boulders at Cape Foulwind indicated a local wetland site and regional shrubland with some tall trees. Moar and Suggate (1979) interpreted the site as representing a stadial in the last (Kaihinu) interglacial, despite radiocarbon ages too young for this interpretation. Earlier work on the Sunday Creek site near Hokitika (Dickson, 1972) had first alerted workers in Westland to the problems of radiocarbon dating in this high leaching environment. At Sunday Creek a single piece of wood from a peat sitting above marine sands and below outwash gravel produced finite radiocarbon ages that varied by more than 7,000 years, and more seriously, were apparently younger than wood samples beyond the range of dating above and below. Cape Foulwind was resampled with the aim of testing for possible contamination by young carbon. Acid and alkali treatment was applied and confirmed the contamination problem (Grant-Taylor and Rafter, 1971). That radiocarbon dating was unreliable was confirmed for Neville Moar (Moar and Suggate, 1979) when peat radiocarbon dated at the same age at Martins Quarry and 'The Hill' had distinctly different pollen assemblages and yet were only 6 km apart. The ca. 33,000 yr radiocarbon age at Martins Quarry was subsequently discounted and the site interpreted as late Kaihinu.

Stop 3 'The Hill', Wilsons Lead Road

From Cape Foulwind to State Highway 6, Wilsons Lead Road crosses fluvially dissected Waites Formation on the raised marine terrace. The road is named after the 'lead' of gold-bearing black sands that was mined at the foot of the cliff at the back of the terrace. Other leads occur further along the road associated with older cliff lines; Addisons at the back of a Marine Isotope Stage 9 terrace was particularly productive. At 'The Hill' the road cuts through a small rise and exposes dune sand over peat. Here Moar and Suggate (1979) chose to accept radiocarbon dates because of their stratigraphic consistency and the similarity of acid and alkali treated samples. Pollen extracted from the sand and the peat record the transition from a mid last (Otira) glaciation interstadial through the last glacial maximum into the post-glacial (shrubland-grassland-forest transition). The site is important for the middle part of the last glaciation that it covers (part of Marine Isotope Stage 3); very few other sites have been found that cover this time span. Vigorous discussion on the field trip of the validity of accepting the radiocarbon dates at 'The Hill' while rejecting others has prompted a resampling of the section for volcanic glass shard counting. Kawakawa Tephra (22.6 14C years) is a widespread although usually microscopic tephra marker that, if found, will provide a cross-check for the radiocarbon ages. Analysis is in progress.

The Coastal Road

South along State Highway 6 the focus became the coastal morphometry and correlation of raised marine benches. Broad shore platforms covered by fluvial gravels such as those at Cape Foulwind formed with ease across the soft Tertiary rocks, whereas the harder Paleozoic crystalline rocks of the Paparoas produced narrow discontinuous benches. South of Charleston the mix of morphometries was well demonstrated by Pleistocene marine benches cut across Paleozoic gneiss and Eocene coal measures. Broad shore platforms are interspersed with uplifted stacks and headlands formed from the harder rocks.

Near Barrytown the effects of differential uplift rate along the coast are apparent in the development of the post-glacial coastal plain and in the morphometry of the Pleistocene marine terraces. In this area, between the headlands of Dolomite Point near Punakaiki and Seventeen Mile Bluff, we passed over a 17 km long 1.5 km wide coastal lowland backed by a post-glacial sea cliff. The lowland is formed from a progradational sequence of gravel beaches, swamps, beach faces and dune ridges. Suggate (1989) mapped two sets of shorelines on the lowland, a younger and an older set. The older set has four shorelines varying in elevation from 3.5 to 8.5 m ASL reflecting regional uplift. The younger set shows no significant altitude difference from present sea-level. A step change in the altitude of the older shorelines occurs across the trace of the south west striking Canoe Fault, which crosses the lowland in the southern half. On the south east (upthrown) side of the fault each one of the four terraces is about 3 m higher than its counterpart on the other side of the fault, indicating a single uplift event occurred after formation of the youngest shoreline. In the north, inland of the post-glacial cliff, broad Pleistocene shore platforms are formed across soft Tertiary sediments, whereas in the south across Canoe Fault the post-glacial cliff is cut into steep mountain slopes formed in hard Paleozoic rocks. A single narrow high level Pleistocene marine bench is recognisable.

Correlation of marine terraces along the coast is confounded by their limited preservation and differential uplift associated with different structural features. Pat tackled this correlation problem (Suggate, 1992) by correlating sequences of coastal marine terraces from Westport to Hokitika to the high sea-levels of the marine oxygen isotope record. This was done by finding the best match of heights between a local terrace sequence and a hypothetical sequence that would be produced by uplifting terraces formed at high sea-level stands of the marine isotope record at an unknown but constant uplift rate. In this manner the local uplift rate and best-fit correlation of terrace ages was established. The uplift rate calculated for the Charleston terraces (0.35 m/ka) was consistent with the uplift rate inferred by Paul Williams (Williams, 1982) from speleothem ages in Metro Cave, which we visited on the Wednesday evening. Prior to Pat's analysis, terrace correlations had been made on the basis of heights alone. His approach led to a unification of disparate nomenclatures and age assignments dating from 1964.

Stage 5 shore platforms at Perpendicular Point viewed from Irimahuwheri Lookout

A number of important sections were passed along the coast but not stopped at for reasons of time or safety. They included Bullock Creek (Moar and Suggate, 1996) and Schultz Creek (Suggate, 1965), which demonstrate the influence of different uplift rates along the coast. Both sites expose beach gravels overlain by peat, containing pollen assemblages characteristic of interglacial flora. The beach gravels are correlated to MIS 5c for both sites but the former lies at 29 m ASL whereas the latter is at 40 m ASL.

The geological and aesthetic qualities of the coastal terraces were viewed at Irimahuwheri Point before heading to Ten-Mile Creek for lunch. A leisurely hour was spent fighting the sandflies and seagulls at the lunch spot and paddling in the tepid Tasman Sea. Rapahoe, 5 km to the south was the last formal stop of the trip, where we stood on the boulder beach to view the Stage 5c, 5e and 9 marine terraces at Point Elizabeth.

On the return trip the pleasures of the Pancake Rocks, Monteiths beer and ice cream were indulged in at Punakaiki as preparation for the evening's conference dinner.

The mid-conference field trip was blessed with good weather, a jovial and inquisitive crowd, and most importantly a couple of distinguished gentleman who saw fit to grace us with the benefit of their experience. On behalf of the field trip participants I wish to express our gratitude to Pat and Neville for their contribution. At well into retirement age, leading field trips can be a tiring experience and I know Pat had his wife Daphne's health to consider at the time. Thanks Pat and Neville for another good day out.

Peter Almond

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AQUA post-conference field tour, 8–9 February, 2003

Coast-to-Coast

Brent Alloway

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The 900 competitors who entered this year's Coast-to-Coast pushed themselves in a gruelling 238 km running, cycling, kayaking slog from Kumara Beach on the West Coast of the South Island to Christchurch on the East Coast. At the same time, a group of dedicated AQUArians were preparing a Coast-to-Coast of their own. Despite recovering from the excesses of the conference, travelling in the relative 'comfort' of mini-vans, and participants being of greatly varied physical ability — I can assure you that the trip was no less gruelling and just as challenging. The trip leaders were Peter Almond (Lincoln University), Phil Tonkin (Lincoln University), Pat Suggate (GNS, retired), Rob Rose (Canterbury University) and Bruce Harrison (New Mexico Tech.).

Figure 1. A fine example of a South Island Chrono-sequence — in chronological sequence is Pat Suggate (left), Phil Tonkin (centre) and Peter Almond (right).

Day 1 was spent looking at the influence of active faulting on the Quaternary sequences. AQUArians were introduced to the effect of the May 1968 Inangahua fault, growing anticlines in the Grey Valley that have tilted terraces near Blackball, and the history of the Alpine Fault. Participants also had the opportunity to look at Quaternary glacial and fluvial sequences and cover-beds. Is it a coincidence that Late Glacial Moraines referred to as younger Larrikan and older Larrikan might be linked in some way to Peter Almond and Pat Suggate who were describing them? Quaternary cover-bed sequences and soil chronosequences were introduced to the participants — it was emphasized that lack of chronology was a major obstacle. Problems associated with radiocarbon dating of organic silts and peats in a high rainfall environment were also outlined. Samples would yield significantly younger and imprecise ages without vigorous chemical ($NaOH/Na_4P_2O_7/HF/HNO_3/KClO_3/NH_3$) pre-treatments.

The evening was spent at the Bealey Hotel — which gained notoriety a few years back when the owner claimed to have photographed a Moa in the bush. The photo was proven to be the rear end of a large deer and the Hotel subsequently received a business publicity award. John Magee (ANU) became very excited when he saw a life-size replica of a Moa outside the Hotel. Our arrival was great timing; the sun was setting, casting spectacular lighting on the bush clad mountains, and the Rugby 7s tournament was also being shown live on TV. What I particularly love about us Kiwis and Aussies is the way we always draw closer together in times of adversity — it bought a tear to my eye to see the Australians amongst us supporting the New Zealand 7s team in the finals against England. Such solidarity, or was it simply payback after England thrashed Australia in the semis ?

Day 2 was spent briefly looking at the Younger Dryas moraines high on Arthurs Pass. When I say briefly — you couldn't actually see them through the dense mist. Actually, there was a brief glimpse of Tim Barrow (ANU) bounding off into the misty grey looking for potential boulders for cosmogenic dating. We then travelled eastwards of Southern Alps to look at Last Glacial — Holocene moraines, terraces and fans. While we were doing this Paul Hesse (Macquarie) was reflecting on why the Indian Ocean, and river and lake waters in New Zealand are blue? I understand that no recreational drugs were involved. An

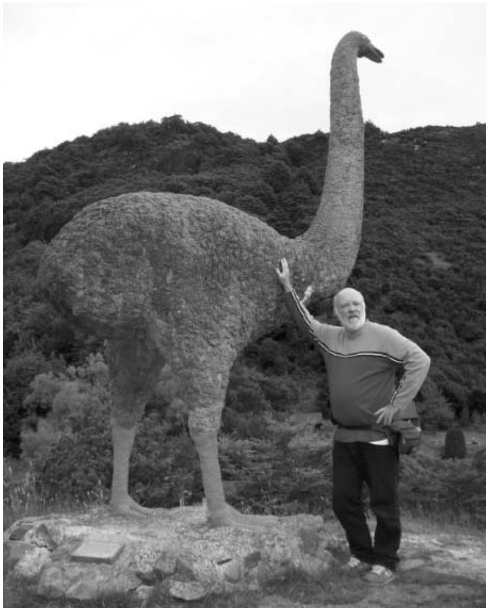

Figure 2. *John Magee (ANU) sharing a few quiet moments with a replica of* Dinornis *— the largest Moa cousin of* Genyornis.

Figure 3. The Coast-to-Coast AQUArians. Is that Craig Sloss (Wollongong) casting an ever so delicate shadow over both Christine Kenyon (Melbourne) and Tristyn Holland (Wollongong)??

important aspect that again came out of this field trip was the lack of chronology but the absolute requirement of having a robust stratigraphic and landscape framework in place before acquiring samples for dating. Another interesting aspect was that understanding the landscape is an important prerequisite for effective land management. For instance, the montane areas east of the Southern Alps were regarded as highly erosional landforms created by sheep grazing and European fires. However, subsequent soil studies have clearly shown that the exposed fans are pre-European and remarkably stable.

The trip was excellent and was certainly a tribute to the tremendous collective knowledge and experience of Peter Almond, Phil Tonkin, Pat Suggate and Bruce Harrison. Our thanks also goes out to the student helpers — Matthew Hughes (Lincoln) and Henrik Rother (Canterbury) for the fine driving and general running around.

As Steve Gurney mentioned as he slumped at the finish line winning his seventh consecutive Coast-Coast victory (in 11hrs 14 mins) — *'I've had enough, I've had my addiction treated.'* Well Steve … don't be a woose … in OUR particular brand of Coast-to-Coast we've neither had enough nor did we have our addictions treated!

The Coast-to-Coast AQUArians were: Brent Alloway, Peter Almond, Tim Barrows, Christine Elliot, Lucy Gayler, Bruce Harrison, Paul Hesse, Alexandra Hilgers, Tristyn Holland, Matthew Hughes, Christine Kenyon, Johanna Lomax, John Magee, Rob Rose, Henrik Rother, Craig Sloss, Pat Suggate and Philip Tonkin.

Travel report on the First NCCR Climate International Summer School, 7–14 September, 2002, Grindelwald, Switzerland

'Rockin' to Interlarken'

Helen McGregor

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Under the towering peaks of the Bernese Alps, and with the ever-retreating Lower Grindelwald glacier in full view, the scene was set for a week-long discussion of all things climate at the first NCCR (National Center for Competence in Research) Climate International Summer School. I attended the workshop with the assistance of an AQUA Travel Prize, and presented my research on high-resolution coral records of mid- Holocene climate in the tropical western Pacific.

The Swiss NCCR Climate was established in 2001 as a centre of research excellence, and is a consortium of Swiss universities and research organisations investigating climate change and its impact on society. The Summer School, forming part of NCCR Climate's commitment to education, was organised into four main themes — palaeoclimate, climate predictability, climate impacts on agriculture and ecosystems, and the economics of climate change — reflecting the diversity of NCCR Climate's programs.

The School took place in a relaxed and informal atmosphere. Invited academics gave interesting and up-to-date summaries of research on the four themes, and it was great to 'cross-examine' the speakers during the lengthy discussion sessions and in-depth workshops.

I valued the different perspectives on climate change issues brought to the meeting by people from different disciplines. Present and future climate change issues were placed in the context of climate change on longer cycles, and the contrast (and ensuing debate) between economists and physicists modelling methodologies was fascinating. I benefited from this multi-disciplinary aspect, by discussing my palaeoclimate results one-on-one with the climate modellers, and received some good feedback on my interpretations.

Of the many excellent lectures, three stood out for me. I enjoyed Dr Ray Bradley's (University of Massachusetts) palaeoclimate lecture, particularly the way he questioned the assumption of a 'stable' Holocene climate, then discussed how climate forcings, at different scales, affect the Holocene. I liked the clear and uncomplicated way Dr Thomas Stocker (University of Bern) reviewed the major sources of uncertainty in climate models, and in data initialising these models. In addition, I found Peter Gregory's (University of Reading) stark presentation on the ability of the world's agricultural systems to meet future demand, with or without greenhouse warming, both shocking and compelling.

The fieldtrip provided a great opportunity to get into the mountains and view some beautiful alpine landscapes, though seeing the all too obvious glacial retreat begged the question: is this a symptom of human-induced greenhouse warming?

The excellent Grindelwald hospitality throughout the week, including an impromptu cowbell parade, helped develop a great comradery between the 70 or so participants. This made it easy to continue discussing climate long after the formal sessions were over. And with an intense week of climate, debates and ideas behind us, we all tuned into American singer Willie Nininger, playing at the local bar, inviting us to head for the hills and join him in 'Rockin' to Interlarken'!

Financial assistance from the Australasian Quaternary Association is gratefully acknowledged.

Summer School participants Camille Li, Dr Clara Dreser and Dr David Battisti in front of the Lower Grindelwald Glacier.

Donald Argyle Adamson

Biologist, Quaternary scientist, naturalist, explorer

Born Arcadia, NSW, November 2, 1931.
Died Sydney, May 5, 2002, aged 70.

With Don's death, the Australian Quaternary community has lost an inspired and inspiring colleague. He died peacefully on 5 May 2002 in the presence of his family. He was 70. A very wide community of scholars around the world, including many of his former students, will miss his encouragement, constant flow of good ideas, and incisive insights into the natural world. Don was by temperament an explorer and a naturalist. He was at home in the icy wastes of Antarctica and the frozen tussocks of Macquarie Island. In 1972 he discovered the excitement of archaeological and geological work amidst the dunes of the Blue and White Nile valleys; the history of the Nile became an abiding interest. He also worked in the plains of the Northern Territory, the volcanic highlands of Ethiopia, the rocky peaks of the Flinders Ranges and the canyons of his beloved Blue Mountains. He was unusually observant, and often saw the things that others missed. I recall the glee with which he spotted a Late Stone Age barbed bone harpoon point next to the very site in central Sudan where Desmond Clark and his archaeologists had been excavating for days, oblivious of this prized find. During that same season he discovered that the potters along the White Nile two thousand years ago used the siliceous spicules of a freshwater sponge to temper their pots which were then traded for many hundreds of kilometres across the Sudan.

From his single teacher school at Arcadia he moved on to North Sydney Boys' High School, where he acquired an enduring love of geography and a mastery of lucidly written English. He graduated with the degree of Bachelor of Agricultural Science from the University of Sydney and after gaining the degree of Doctor of Philosophy in plant physiology, he conducted postdoctoral research as a CSIRO Fellow and National Research Council of Canada Scholar. From 1962 to 1968 he taught in the Botany Department at Sydney University before moving to the School of Biological Sciences at the newly established Macquarie University, where he taught until 1995, becoming a Senior Research Fellow there after nominal retirement. When Don left Canada he was at an intellectual crossroads: to stay with plant physiological processes or to develop his love of landscape history, nurtured during his days out bush in central Australia with Bob Crocker. He opted for landscape, but retained his love of plant biology throughout his life.

Don was ever generous with scientific advice and wise counsel, even when we did not always wish to receive such counsel. He served on the Advisory Council of the National Parks and Wildlife Service of New South Wales, the Council of the Linnean Society of NSW (and treasurer), and the Scientific Advisory Committee of the Royal Botanical Gardens NSW. His intellectual rigour and good sense were also appreciated on the Program Advisory Committee for Earth Sciences and for Biological Sciences of the Antarctic Division. With his breadth of interest and expertise in biology, earth sciences, natural history and archaeology, Don possessed the intellectual curiosity of a Renaissance scholar. He was unfailingly modest, tough and cheerful, and a generous host. His published books and papers testify to the range and interdisciplinary nature of his research interests as well as to his clarity of thought and expression.

Don is survived by his wife Heather, his three children Alistair, Ian and Erica and his granddaughter Rachel. His insights and ideas continue to inspire but he is sorely missed by friends and colleagues who, like me, were privileged to work with him.

Martin Williams
University of Adelaide

Australasian Quaternary Association

Financial Statement for 2002

INCOME AND EXPENSE REPORT (1 January 2002 to 31 December 2002)

Uncommitted balance brought forward	***$30,503.55***	$***30,132.89***
	2002	**2001**
INCOME		
Business income – Concession	1,240.00	805.00
Business income – Full	3,770.00	3,755.00
Business income – Institute	467.32	469.13
Business Income Total	**5,477.32**	**5,029.13**
C'wealth Bank Interest	43.56	28.29
Bank Melbourne Interest (12 month)	524.50	1,279.95
Bank Melbourne Interest (6 month)	479.59	
Bank Interest Total	**1,047.65**	**1,308.24**
Port Fairy income	195.30	13,834.20
Miscellaneous income (bank refund & adjustment)		18.06
Quaternary Australasia income		5.00
Quaternary International special issue	425.00	2,300.00
TOTAL INCOME	**7,145.27**	**22,494.63**
EXPENSES		
QA expense – printing	1,636.00	3,788.00
QA Expenses	30.00	30.00
Commonwealth Bank fee		
FID		11.15
GDT	15.60	33.80
Merchant bank fee	208.18	1,041.37
Bank Fees Total	**223.78**	**1,086.32**
Australian Geosciences Council	550.00	
Science Meets Parliament Forum	99.00	198.00
Prize – travel	1,500.00	1,000.00
Incorporation cost		60.00
Postage	841.48	464.11
General expenses		100.00
Committee expenses	284.45	
Quaternary International cost		3,200.00
Refund AAV		25.00
Refund		50.00
Port Fairy – accommodation		2,654.00
Port Fairy – refund		589.00
Port Fairy – Excursion guide		495.00
Port Fairy – administration		580.79
Port Fairy – Food and drink		5,853.19
Port Fairy – insurance		891.00
Port Fairy – student prizes		850.00
Port Fairy – student subsidy		200.00
Port Fairy – T-shirt		9.16
Total Port Fairy Costs		**12,122.14**
TOTAL EXPENSES	**5,164.71**	**22,123.97**
INCOME LESS EXPENSES	**1,980.56**	**370.66**
Transfer Bank Melbourne – C'Wealth Bank	**3,058.28**	
Assets (31 December 2002)		
Commonwealth Bank account	8,847.50	4,812.32
Bank of Melbourne Term Deposit (6 month)	10,000.00	12,578.69
Bank of Melbourne Term Deposit (12 month)	13,636.61	13,112.54
TOTAL	**32,484.11**	**30,503.55**

I have examined the records of the *Australasian Quaternary Association* and I am of the opinion that the above Income and Expense Report gives a true and fair view of the affairs of the Association for the year ended 31 December 2002. *Dick Adair*

A simple and fast method for calculating the area of macroscopic charcoal isolated from sediments

Scott D. Mooney and Manu Black
School of Biological, Earth and Environmental Sciences, University of New South Wales, Sydney, NSW 2052

Mooney and Radford (2001) presented a method for the quantification of larger charcoal fragments, which had been washed from volumetric subsamples of sediment. As noted in that paper, there has been a distinct move towards the quantification of larger charcoal fragments overseas, as it is believed that these particles better reflect the occurrence of fire at the catchment (spatial) scale (Clark, 1988). By 'larger particles' or 'macro-charcoal' we are referring to charcoal particles that have at least one axis longer than those traditionally quantified in palynological studies (e.g. Clark, 1982). In practice, this separation between 'point-count charcoal' and macro-charcoal probably occurs at about 50mm.

The method described in Mooney and Radford (2001) was only slightly modified from what has become known as the 'Oregon sieving method'. Descriptions by Millspaugh and Whitlock (1995), Long et al. (1998) and Gardner and Whitlock (2001) provide details of the method as used by the members of the Environmental Change Research Group in the Department of Geography at the University of Oregon, USA.

Mooney and Radford (2001) also noted that image-analysis software could be usefully applied to the quantification of macro-charcoal. Since the publication of that paper, we have been working towards simple methods to further refine the methodology, and in particular, to use easily available software to quickly calculate the *area* of charcoal in volumetrically standardised sediment samples.

At UNSW we have typically been expressing charcoal (of a particular size fraction, for example >250mm) as abundance (i.e. number of particles) per unit of (fresh) sediment volume (no./cm^3), for example in Mooney et al. (2001). Nonetheless, we recognise several limitations with expressing charcoal in this way. Abundance of charcoal per unit volume may be most appropriate where the size of individual charcoal fragments remains relatively constant throughout a (sediment) profile, which is unlikely if the distance to the source of the charcoal (i.e. the fire), or fuel type, to give two examples, varies through time.

It is also easy to imagine how portraying charcoal as a count per unit volume may result in erroneous trends. For example, one large charcoal fragment approaching 1.0cm^3 in a 1.0cm^3 sediment subsample will result in a count of 1.0. An adjacent subsample with 10 small fragments in an equivalent volume would appear to have 10 times as much charcoal. This is obviously a problem, considering that charcoal is generally brittle, so any breakage (due to handling etc) could result in a higher charcoal count (Clark, 1984). One obvious solution to this is to quantify charcoal in terms of area per volume of sediment.

As Clark and Hussey (1996) have previously noted, comparison between sites is best accomplished with standard units. In a review of Australian fire history Kershaw et al. (2002, p. 5) noted 'there is also a lack of consistency in methods of counting and portrayal of charcoal data' and that this made their overview more difficult. It is hence also the aim of this paper to provide a simple method, thereby potentially facilitating future comparisons between sites in Australia.

The Method

Follow Steps 1–3 in Mooney and Radford (2001). This results in charcoal of a known size fraction sieved from a known volume of sediment dispersed in water in a petri-dish. The concentration of material should be such that very few charcoal fragments are overlapping: experimenting with the volume of sediment used in the sieving operation can reduce this concern. We have been using charcoal fragments greater than 250mm and so cannot comment on the efficiency of the method for smaller charcoal particles. Nonetheless, we suspect that the recognition of smaller charcoal particles (at Step 5 below) may be a problem.

The method described below uses Scion Image, which is free software available at www.scioncorp.com. Before downloading the software you are required to register, however, this is a simple and fast procedure. Scion Image for Windows is based on NIH Image, which runs on a Macintosh platform. The method described below uses Scion Image release Beta 4.0.2. The method also requires a digital camera to capture images and Adobe Photoshop to save the images in the required format.

Step 1. Acquiring a digital image

Using a digital camera take a fine-resolution image of the petri-dish with the collected material. The method works best if the charcoal fragments are towards the centre of the petri-dish. The use of a tripod to support the camera keeps the images at a set size and minimises movement. A scale (such as a ruler) and a label (including site name, depth of sample, etc.) should be placed next to the petri-dish. Adjust the zoom of the camera and/or the height of the tripod so that the entire petri-dish, scale and label are included in the image. If extra light is needed placing the petri-dish on a light table minimises shadows. Keep the petri-dish (with collected material) for further use (see Step 5 below).

Repeat Step 1 until a good image of all samples has been obtained. Download the images from the camera into a labelled folder on the PC with Adobe Photoshop and Scion Image already installed.

Step 2. Formatting the image for processing

Open one of the images using Adobe Photoshop. First re-size the image, adjust the contrast and brightness and then save the image as a bitmap file (*.bmp). If you are familiar with Photoshop you can record all of this as an 'Action'. We have been reducing our images to 35% (with 'constrain properties' ticked and using the 'bicubic interpolation') before saving them. Scion Image analysis can also be used with *.tif formatting but not *.jpg.

Step 3. Calibration

Open the *.bmp file in Scion Image. Calibration sets the scale for the image and can be done by selecting the tool that allows you to draw a straight line (5th tool down on the right in the tool box, see Figure 1). Go to the ruler (within your image) and draw a straight line over a known distance (X). Then select >*Analyse* >*Set scale* from the drop-down menus. Fill in the table that appears, making sure that you first change the units to 'mm' and fill in your known distance (X). To check if the calibration of the scale is correct select >*Analyse* >*Measure* and then >*Analyse* >*Show results* (this should tell you the distance in mm along your straight line, X). You should only need to do this calibration once in any session (i.e. while Scion Image is open), assuming that the size of your images does not change. Nonetheless, it may be a good idea to check the calibration every 10 samples or so.

Step 4. Setting measurement parameters

Select >*Analyse* >*Options* from the drop-down menus and set the maximum measurement as 8000. Then use the circle tool (2nd tool on the right in the tool box, see Figure 1) to select the area to be analysed (remembering to hold the shift key down to make it a perfect circle). The area to be analysed should include all charcoal particles within the petri-dish. The selected area can also be moved around using the arrow keys.

Step 5. Analysing and showing results

Select >*Options* >*density slice* from the drop-down menus. The density slice option allows all pixels between an upper and lower threshold to be selected. The LUT (Look-Up Table) tool bar, which should then appear on the left-hand side of the screen, is used to set these thresholds. This is the most subjective stage of the procedure, and hence it is handy to have the original sample (petri-dish with charcoal) on hand to compare with the selection from Scion. Moving both the upper and lower limit in the LUT tool bar up or down either selects or deselects material in the petri-dish (see Help in Scion). By comparison with your original, all charcoal particles in the sample should be highlighted in the Scion image. This may take some practice: experimenting with

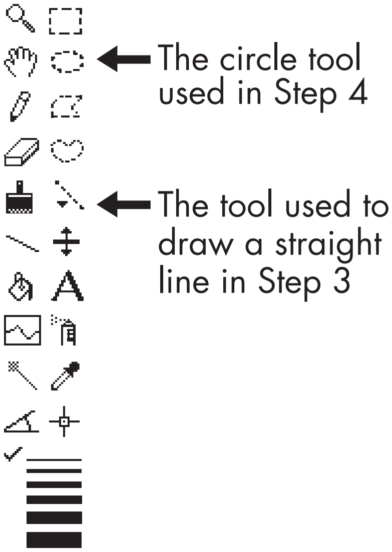

Figure 1. The tool box in Scion Image with the necessary tools highlighted.

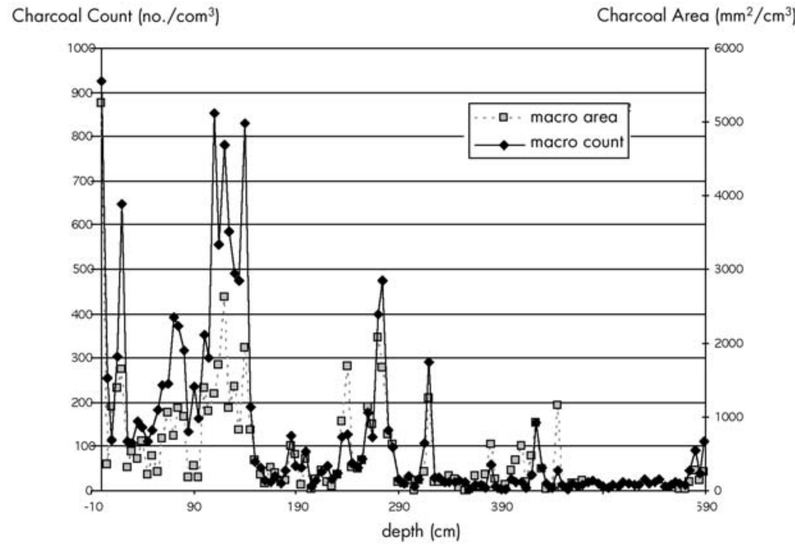

Figure 2. A comparison of the count and image analysis-derived charcoal data from the Gooches Crater (Right) site.

charcoal in water solutions with and without other materials may help this process. We always set the lower threshold on the LUT tool bar to the base (256 or pure black) but vary the upper threshold so that all charcoal particles are selected.

Select >*Analyse* >*Analyse particles* from the drop-down menus, making sure the following boxes are ticked: 'Label', 'Outline', 'Reset'. Also make sure that min = 1, max= 99999 are chosen.

Select >*Analyse* >*Show results* from the drop-down menus and a table will appear showing the results of the different parameters for **each** charcoal fragment. Select >*Edit* >*Copy measurements* from the drop-down menus and the results can then be pasted into an Excel workbook. Areas, expressed as mm^2, can then be summed to get the total area of charcoal for that sample. The number of particles can also be recorded. Other useful statistics can also be calculated, such as modal charcoal size, standard deviation, etc.

Concluding Remarks

There are still several important issues regarding fire history in Australia that are contentious or poorly understood. This suggests that much work is still required. We have found that the image processing method described above is relatively simple and with practice, it can be extremely fast. This speed then allows more samples to be analysed, allowing either a finer temporal resolution or a better spatial resolution of study sites.

We have also compared the expression of charcoal data as abundance to the image analysis method described herein and found the results to have a very high correlation. Figure 2 demonstrates this correlation ($r^2 = 0.71$, $p<0.01$) using data derived from a site we have been working on, Gooches Crater (Right). Gooches Crater (Right) is an unnamed valley swamp in an adjacent catchment to Gooches Crater, which occurs to the west of Sydney (at approximately 33º27'255'S, 150º 16'020'E). In Figure 2 some differences between the charcoal counts and charcoal area are discernible, particularly in the top 130cm. Such differences are to be expected and may reflect relevant variables such as changing fuel sources or fire intensity. Comparison between charcoal counts and area is possible with the method described herein, as the number of particles summed in Step 5 gives the total count per cubic centimetre of sediment.

Finally, the method described herein results in charcoal data expressed as area per cubic centimetre of sediment. This is similar to the results provided by 'Point Count Charcoal' (Clark, 1982) and hence provides a means for comparison with previous work. Furthermore, the method is simple and relatively fast, and is compatible with a method that is becoming standard overseas.

Acknowledgements

Geoff Hyde and Geoff Horn (both UNSW) helped with our understanding of Scion Image. Discussion with Janelle Stevenson (ANU) also helped clarify interpretation of the differences between charcoal counts and area. Janelle also suggested using a light-box for the photography. The Gooches Crater (Right) core was obtained with the help of Joe Leech and Chris Cobb. Nikki Franklin (U. Syd.)

and Emma Maltby (UNSW) tested the methodology and offered useful suggestions. Thanks also to Nic Dolby and an anonymous referee for valuable comments on this paper.

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THESIS ABSTRACTS

Beyond the Divide

A new geoarchaeology of Aboriginal stone artefact scatters in western New South Wales, Australia

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Surface scatters of stone artefacts are the most ubiquitous feature of the Australian Aboriginal archaeological record, yet the most underutilized by archaeologists in developing models of Aboriginal prehistory. Among the many reasons for this are the lack of understanding of geomorphic processes that have exposed them, and the lack of a suitable chronological framework for investigating Aboriginal 'use of place'. This thesis addresses both of these issues.

In arid western NSW, erosion and deposition accelerated as a result of the introduction of sheep grazing in the mid-1800s has resulted in exposure of artefact scatters in some areas, burial in others, and complete removal in those parts of the landscape subject to concentrated flood flows. The result is a patchwork of artefact scatters exhibiting various degrees of preservation, exposure and visibility. My research at Stud Creek, in Sturt National Park in far western NSW, develops artefact and landscape survey protocols to accommodate this dynamic geomorphic setting. A sampling strategy stratified on the basis of landscape morphodynamics is presented that allows archaeologists to target areas of maximum artefact exposure and minimum post-discard disturbance. Differential artefact visibility at the time of the survey is accommodated by incorporating measures of surface cover which quantify the effects of various ephemeral environmental processes, such as deposition of sediments, vegetation growth, and bioturbation, on artefact count.

While surface stone artefact scatters lack the stratigraphy usually considered necessary for establishing the timing of Aboriginal occupation, a combination of radiocarbon determinations on associated heat-retainer ovens, and stratigraphic analysis and dating of the valley fills which underlie the scatters, allows a two-stage chronology for hunter-gatherer activity to be developed. In the Stud Creek study area, dating of the valley fill by OSL established a maximum age of 2,040±100 y for surface artefact scatters. The heat-retainer ovens ranged in age from 1,630±30 y BP to 220±55 y BP. Bayesian statistical analysis of the sample of 28 radiocarbon determinations supported the notion, already established from analysis of the artefacts, that the Stud Creek valley was occupied intermittently for short durations over a relatively long period of time, rather than intensively occupied at any one time. Furthermore, a gap in oven building between about 800 and 1,100 years ago was evident. Environmental explanations for this gap are explored, but the palaeoenvironmental record for this part of the Australian arid zone is too sparse and too coarse to provide explanations of human behaviour on time scales of just a few hundred years.

Having established a model for Stud Creek of episodic landscape change throughout the late Pleistocene and Holocene, right up to European contact, its veracity was evaluated in a pilot study at another location within the region. The length of the archaeological record preserved in three geomorphically distinct locations at Fowlers Gap, 250km south of Stud Creek, is a function of geomorphic dynamics, with a record of a few hundred years from sites located on channel margins and low terraces, and the longest record thus far of around 5,000 years from high terrace surfaces more remote from active channel incision. But even here, the record is not continuous, and like Stud Creek, the gaps are interpreted to indicate that Aboriginal people moved into and out of these places intermittently throughout the mid- to late Holocene.

I conclude that episodic nonequilibrium characterizes the geomorphic history of these arid landscapes, with impacts on the preservation of the archaeological record. Dating of both archaeological and landform features shows that the landscape, and the archaeological record it preserves, are both spatially and temporally disjointed. Models of Aboriginal hunter-gatherer behaviour and settlement patterns must take account of these discontinuities in an archaeological record that is controlled by geomorphic activity.

I propose a new geoarchaeological framework for landscape-based studies of surface artefact scatters that incorporates geomorphic analysis and dating of landscapes, as well as tool typology, into the interpretation of spatial and temporal patterns of Aboriginal hunter-gatherer 'use of place'.

The Muddle in the Middle

Temporal and regional variation in the evolution of Homo during the Middle Peistocene and beyond. A morphometrical approach

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Variation evident in fossil crania of Homo from the Late and Middle Pleistocene has been interpreted as temporal and regional variants of one species: Homo erectus. Recently this has been questioned and it has been suggested that a number of species characterise the evolution of Homo during this period. That Homo erectus existed in Africa from 1.7 million years ago has been challenged by those who view the range of variability between the Asian and African crania as too broad to be included in one species and thus propose that the African specimens represent another species: Homo ergaster. That Homo erectus existed in Europe and Africa from 600,000 years ago has also been challenged by those who view the fossils in Asia and the fossils in Europe as representing two species: Homo erectus in Asia and Homo heidelbergensis in Europe and Africa. The meaning of variation within each of these regions has also been the focus of attention.

These issues are addressed in this thesis. A morphometric approach is taken, in which cranial data for Homo from 1.7 million years ago when Homo first extended its range into Europe from Africa, until 140,000 years ago, are compiled. Principal Component Analysis and Discriminant Analysis are used.

Crania of fossil Homo and extant Pan are compared to provide some indication of whether more than one species is represented by Homo. This model is based upon the premise that the variation evident in Pan, the nearest relative of Homo and comprising two species that separated over 2 million years ago, could represent the expected species variation in past populations of Homo. More than two species are represented in Homo. A framework for the evolution on Homo is proposed, and models of the evolution of Homo are examined in the light of this framework.

Westport, New Zealand, February, 2003

Prize-winning student abstracts from the AQUA biennial meeting

The history of algal blooms in the Myall Lakes, NSW

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The Myall Lakes, 50km north of Newcastle, Australia, are quite unique among the hundreds of coastal lakes lining the NSW coast. They are a barrier lake system covering 10,000ha, and are brackish (ranging from Oligohaline to Mesohaline under the Venice System classification), with only two small streams providing a freshwater input. Flushing times for some parts of the Lakes are in the order of 600 days. This long water-retention time is of concern, because any changes to nutrient regimes, or pollution in the catchment affecting the Lakes, may take a long time to be corrected. So far, the Myall Lakes are far less disturbed than similar coastal lakes, and as an important migratory bird habitat, they are protected under the RAMSAR agreement. They are also fully encompassed by the Myall Lakes National Park, declared in 1972, and are important to the local tourism and fisheries industries. Concern has arisen, however, over a series of cyanobacteria blooms in recent summers. Are these blooms an indication that human influences are affecting the Myall Lakes?

Four sediment cores, up to 95cm long, were taken in February and September this year. Sub-samples taken at 0.5cm intervals were analysed for trace elements, palynological assemblages, sediment grain size and organic/carbonate content. ^{210}Pb was used to date the cores and determine sedimentation rates. An important aspect of this investigation was the use of fossilised algal remains, specifically the akinetes of cyanobacteria, to estimate previous algal populations in the lake system. Preliminary results indicate that there have been cyclical fluctuations in the populations of aquatic plants and algae throughout recent history. Population trends and the likelihood of their relationship to anthropogenic and climatic influences on the catchment will be discussed (See Figure 1).

The reconstruction of past environments using fossilised cyanobacteria has the potential to be an important tool in catchment management.

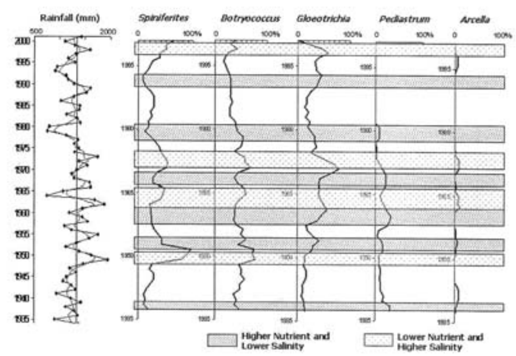

Figure 1. Microfossil abundance variations in BW1 core – shown as percentage of pollen sum.

Abrupt environmental change over the LGM-Holocene transition recorded in lacustrine sediments from Onepoto maar crater, Auckland

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We present the initial results from an near-continuous, high-resolution record of lacustrine sedimentation obtained from the former Onepoto

Crater maar lake in the Auckland region. The section of interest spans the period from ca. 28 to 7.4 ^{14}C kyr BP during which ~4m of laminated organic-rich sediments accumulated in a quiescent freshwater lake. Interbedded tephra from distal sources are present throughout the sequence, and the excellent record of rhyolitic tephra from the Taupo Volcanic Zone, supported by AMS ^{14}C ages, provides a well-constrained chronology for the sequence. Environmental changes within the lake and catchment are deduced from downcore variations in a range of physical, chemical, and biological indicators including: sediment texture, major oxide and trace element chemistry, total organic matter content, elemental carbon /nitrogen ratios, $\delta^{13}C$, magnetic susceptibility and diatom assemblages. These indicators have allowed us to infer changes in the extent and productivity of vegetation in the lake and catchment, as well as changes in the sediment source. In particular, the bulk organic matter content of the sediments has preserved a high-resolution record of vegetation response to climate perturbations, even during climatic events that were probably insufficient to induce a major changes in the vegetation cover. Two key aspects of this record are: (a) variations in the $\delta^{13}C$ of sediment that reflects changes in water supply and atmospheric CO_2 concentrations; and (b) an indication of plant productivity from variations in the amount of organic matter incorporated into the sediments (TOC / LOI / CAR). These indicators provide a complimentary record of environmental changes, indicating: (1) an interval of low plant productivity and reduced $\delta^{13}C$ fractionation (dry) leading up to 14 ^{14}C kyr BP; when (2) there are indications of an amelioration of climate with increasing plant productivity accompanied by increased $\delta^{13}C$ fractionation (wetter and increased atmospheric and aquatic pCO_2); followed (3) by an abrupt climate reversal during the lateglacial with a marked decline in biomass productivity and $\delta^{13}C$ enrichment suggesting cooler and/or drier conditions at ~11–10 ^{14}C kyr BP; and finally (4) the onset of early Holocene conditions with high productivity and increased $\delta^{13}C$ fractionation. The details of the palaeoenvironmental interpretations from these and other indicators will be discussed.

The apparent reversal of the lateglacial amelioration of climate at ~11–10 ^{14}C kyr BP and bound by the Waiohau (ca. 11.9 ^{14}C kyr BP) and Opepe (ca. 9.1^{14}C kyr BP) tephra in the Onepoto Crater sediments is of particular significance to reconstructions of climates during the deglaciation in New Zealand. The presence/absence of a lateglacial climate reversal is controversial in the New Zealand context, with uncertainty arising from the nature of the proxies, and the low-resolution and poor age control of the mostly short-core pollen sequences used in the environmental reconstructions. However, the lateglacial climate reversal apparent in the Onepoto Crater record seems to correlate with that from Kaipo Bog in the eastern North Island (also constrained by Waiohau and Opepe tephra), as well as with isotopic variations in speleothems from Mt Arthur in NW Nelson, and glacial advances in the Southern Alps. This suggests that a lateglacial reversal in climate was probably a regional event, although whether it correlates with other events (YD or ACR) is still unclear.

Mid-Holocene climate change based on the age and geochemistry of stalagmites from Cliefden Caves, central New South Wales, Australia

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Three stalagmites (MC2, MC11 and MC16) were collected from Murder Cave in the Cliefden Caves system, central NSW, Australia (Figure 1). Each displayed a distinctive hiatus in deposition towards the tip. The conditions necessary for speleothem growth are adequate effective precipitation (percolation water), and sufficient soil CO_2 to drive hydrolysis (carbonic acid formation) which produce aggressive water for bedrock dissolution (Baker et al., 1996). As such, the presence of growth hiatuses in stalagmites may indicate a reduction in effective precipitation and/or biological activity due to climate change. Consequently, this study addresses several questions. First, did the presence of the hiatuses represent a synchronous regional response to mid-Holocene climate change? Second, is there geochemical and morphological evidence that indicates that these depositional breaks were climate-driven? Third, if the breaks were synchronous and climate-driven, could they be related to other palaeoclimatic proxy records?

Each of the stalagmites was initially dated by uranium-series alpha-spectrometry and shown to be of Holocene age. Subsequent thermal ionisation mass spectrometric (TIMS) ages show that two of the stalagmites commenced growth during the Holocene (MC2: 9.0 ± 0.4 ka and MC11: 8.5 ± 0.3 ka) while the basal age of the third stalagmite gave 18 ± 1.3 ka. Radiometric ages just prior to the hiatuses of MC2 and MC16 are indistinguishable (4.9 ka ± 0.20 ka and 5.1 ka ± 0.15 ka respectively). Growth resumption of stalagmite MC2 occurred at 3.8 ± 0.20 ka, while for MC16 growth resumed at 0.91 ± 0.61 ka and coincided with a slight shift in drip point, suggesting a physical impediment or alteration to the karst plumbing (Fairchild et al., 2000).

Previous studies of the Late Quaternary have indicated that a mid-Holocene cooling and/or drying event occurred in southeastern Australia at about 5 ka (e.g. Margraf et al., 1992) which was related to the intensification of the high pressure cell over central Australia. This resulted in a reduction in southward penetration of summer monsoonal rains (Shulmeister, 1999). The loss of the summer monsoonal rainfall would have changed the regional hydrological balance whereby potential evaporation (Ep) equals actual evaporation (Ea) seasonally (Cepelecha, 1971), with recharge to the cave system and potential run off occurring maximally during the winter season of reduced Ea. Research indicates a greater penetration of summer monsoonal rain prior to 5 ka in central-western NSW (Williams, 1994). The presence of significant hiatuses at about 5 ka in stalagmites MC2 and MC16 indicates a response to less effective precipitation and possibly an accompanying cooling event. While current research indicates that calcite precipitation in Murder Cave is occurring during the summer months (McDonald, unpublished PhD data) despite a net soil water deficit (especially under the current drought conditions), speleothem deposition is not widespread in the caves system. However, if accompanied by lower temperatures, as indicated by other palaeoclimate proxies at about 5 ka (e.g. Singh et al., 1981), the lowering of soil CO_2 levels would have further decreased speleothem growth rate (Dreybodt, 1980; Baker et al., 1998). This would possibly result in significant breaks in speleothem growth.

Previous studies have shown that stalagmite trace element geochemistry may vary in response to changes in vadose hydrology and thus recharge (Fairchild et al., 1996). Changes in trace elemental geochemistry for the three stalagmites prior to and following the growth hiatus show discordant trends. MC2 and MC11 show increasing Mg/Ca, Sr/Ca, Ba/Ca ratios along the stalagmite growth axis approaching the hiatus. Modern drip water chemistry at this site (McDonald, unpublished PhD data) shows such patterns occur following periods of reduced precipitation. Reduced recharge results in a decrease in the rate of percolation and longer soil-water and water-bedrock contact times which can lead to elevated trace element concentrations in the cave drip waters and also calcite precipitation in fractures above the cave (Fairchild et al., 2000). Prior calcite precipitation results in elevated and co-varying Mg/Ca and Sr/Ca drip water ratios (Fairchild et al., 1996). Such ratios are mirrored in the geochemical response of the stalagmite. MC16 shows this same trend after the hiatus when receiving drip water from a single static point.

The MC16 response differs from MC2 and MC11 in that Mg/Ca, Sr/Ca, Ba/Ca ratios remain reasonably constant and actually decrease slightly prior to the hiatus. However, after the resumption of calcite growth, the trace element signal increases markedly in a similar fashion to MC2 and MC11. This prompts the question as to why the geochemical response of the stalagmites is different prior to the hiatus and also the validity of using speleothem geochemical trends as palaeoclimatic indicators. The morphology of MC16 reveals that the growth axis starts to migrate from approximately 4.5cm below the hiatus. This indicates the cave drip water to be continually finding a new pathway due to the non-vertical growth of the speleothem feeding the stalagmite. This is possibly due to a blockage in the original pathway, a result of prior calcite precipitation and is characteristic of drying conditions (Fairchild et al., 2000). However, the geochemical response of a migrating drip source cannot be explained in terms of longer residence times or prior calcite precipitation, and has not been discussed previously in literature. Possible explanations may include a slower drip incidence allowing for maximum equilibration between trace elements and calcium, resulting in lowering of the Mg/Ca and Sr/Ca ratios. However, ongoing modern drip water and calcite research by the senior author may well provide the answer.

The oxygen and carbon stable isotope signal of the three stalagmites is complex. Both MC2 and MC11 show a trend towards higher delta values nearing the hiatus. In the case of $\delta^{18}O$, this may indicate cooling conditions, whilst for $\delta^{13}C$ a combination of kinetic fractionation due to the slowing drip rate and reduced biological activity may be the trigger (Hendy, 1971). While the correlation between $\delta^{13}C$ and $\delta^{18}O$ ($r^2 = 0.79$, $n = 6$) prior to the hiatus of MC11 may support the presence of kinetic fractionation processes, it could also be explained by the response of both signals to the same environmental processes (Hellstrom et al*.*, 1998). In this case, it is suggested that decreasing temperatures may have occurred at this time, since there is a negative correlation between temperature and $\delta^{18}O$ at Cliefden (McDonald, 2000), and similarly accompanied by reduced soil zone biogenic processes. Consistent with its differing trace element response, stalagmite MC16 also displays different isotopic trends, showing no correlation between carbon and oxygen isotopes and a tendency towards isotopically lighter values nearing the hiatus, in contrast to MC2 and MC11.

In conclusion, the timing of two hiatuses in coeval stalagmites at ca. 5 ka, together with their trace element and morphological analyses suggests a significant climate-driven drying of the aquifer at this time. The oxygen isotope record may indicate cooling conditions and lessened biological activity, but needs further corroboration from the isotopic data of other coeval stalagmites. Nevertheless, two of these stalagmites provide for the first time chronological and geochemical evidence for a climate-driven drying and cooling episode on the central-western slopes of NSW and is valuable supporting data for the timing of a mid-Holocene climate change indicated by other palaeoclimate proxies (e.g Markgraf et al., 1992). In addition, the commencement of growth of two of the stalagmites at ~9.5 ka also provides evidence of a warmer and wetter palaeoclimate at that time.

The timing of resumption of growth following the significant break at ~5 ka is varied between the stalagmites and can be explained morphologically. Further research is necessary to validate the timing and climatic reason for resumption of growth after the drying episode at 5 ka.

Acknowledgements

McDonald gratefully acknowledges the financial support of an Australian Postgraduate Award and an Australian Institute of Nuclear Science and Technology (AINSE) Postgraduate Award. The authors thank A and R Dunhill for unlimited access to their property 'Boonderoo'. Thanks also to B Howlett, D Marsh and members of Orange Speleological Society without whose assistance cave access would not be possible.

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Figure 1. Location map showing Cliefden Caves.

Salinity and vegetation history in south western Australia: preliminary results

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The aim of this research is to investigate the salinity and vegetation history of an area within the highly bio diverse, southwest region of Western Australia, where paelaeoenvironmental and palaeoclimatic research is limited. The study area, which is located approximately 90km north-west of Albany, Western Australia, has a Mediterranean type climate. Proxy indicators from lake and swamp sediments are the means by which past environmental and climatic conditions for the area are inferred. The proxy indicators used for this research include microfossil assemblages of diatoms, pollen and charcoal in conjunction with geochemical, stratigraphic, x-ray diffraction and transmission electron microscopy data obtained from the sediments. These proxy indicators provide the data to construct a record of past lake conditions, past vegetation types surrounding the lakes and past fire regimes in the area. Using analogies to present-day conditions and processes, past environmental and climate conditions will be inferred from these records.

The stratigraphy of cores taken from the study area indicate the occurrence of change, but do not provide a meaningful indication of the type of change that has occurred or over what time frame. Loss on ignition results show change for each of the sites. Sediment pH and eC varies within and between sites. Initial geochemical analysis shows very high phosphorus in the upper 30 centimetres of the lake cores. This is a reliable indicator of European impact, as native south western Australian soils tend to be very low in phosphorus. Further geochemical analysis is currently underway. Initial pollen analysis has not been conclusive but the diatom analysis is showing changes in the salinity of the lakes and swamp. Magnetic susceptibility curves determined for the lake sediments indicate subtle change and further palaeomagnetic analysis is ongoing. The observed changes in the proxy data records cannot be put into a meaningful temporal context because results of AMS dating have yet to be finalised.

This research provides a valuable contribution to unravelling the highly complex processes driving environmental and climate conditions of the present and past, in a region where recent human impact has dramatically altered the landscape.

Dating Holocene estuarine successions using aspartic acid racemisation

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Amino acid racemisation is a chemical dating method that measures the relative abundance of amino acid isomers preserved within organic materials (expressed as a D/L ratio). It has been successfully applied to the dating of marine and terrestrial molluscs, teeth, bone, and aeolanites (Rutter and Blackwell, 1995). Traditionally, amino acid racemisation has been used in the dating of Quaternary sedimentary successions (e.g. Murray-Wallace and Kimber, 1987; Murray-Wallace, 2000 and references therein). Goodfriend (1992) has shown that the fast racemising acid, aspartic acid (Asp) may be applied in the dating of recent sedimentary successions younger than 600 years (Goodfriend et al., 1992; Goodfriend et al., 1996; Goodfriend and Stanley, 1996). Thus, the racemisation of aspartic acid has the potential to provide a geochronology for Late Holocene to recent sedimentary successions that are otherwise difficult to date using more conventional dating techniques such as radiocarbon dating. For example, aspartic acid racemisation can provide a chronology for sedimentary successions that are >120a where 210Pb has reached its limit, and <600a where dating marine and estuarine material with the radiocarbon method is complicated by the marine reservoir effect.

The potential of aspartic acid to provide a chronology for geologically-young sedimentary successions was confirmed by comparing the kinetic trend of Asp observed in laboratory-induced racemisation established by simulated aging (heating) experiments and the degree of Asp racemisation observed in radiocarbon dated fossil specimens of *Anadara trapezia* and *Notospisula trigonella* both common species of estuarine bivalve molluscs (Figures 1 and 2). This was achieved using eight fossil samples of *A. trapezia* and five fossil samples of *N. trigonella* that were analysed by the radiocarbon and amino acid racemisation methods. This permitted a direct comparison between the degree of aspartic acid racemisation under ambient diagenetic temperatures and fossil age established by the radiocarbon dating method (Figures 1 and 2).

The results from the time-series experiments on fossil molluscs, together with the initial modern aspartic acid D/L value, support the apparent parabolic kinetic trend of aspartic acid for both *A. trapezia* and *N. trigonella*. The apparent parabolic nature of the time-series experiment can also be seen in the relationship between D/L ratios and the square-root of radiocarbon ages which yielded a near-linear relationship within the reaction range (cf. Mitterer and Kriausakul, 1989; Goodfriend, 1990; Figure 3). The high $R2$ values of 0.93 for *A. trapezia* and 0.95 for *N. trigonella* indicate that there is only a minor deviation from the trend line.

Using the fossil time-series data for *A. trapezia* and similar results for the estuarine mollusc *Notospisula trigonella*, numeric ages based on the degree of aspartic acid racemisation were determined using an apparent parabolic kinetic model (Mitterer and Kriausakul, 1989; Goodfriend, 1990; Murray-Wallace and Kimber, 1993). Accordingly, for both *A. trapezia* and *N. trigonella*, numeric ages based on the degree of aspartic acid racemisation were calculated using the following formula (Mitterer and Kriausakul, 1989):

$$t = [(D/Ls - D/Lm) / Mc]^2$$

where:

- t is age;
- D/Ls is the average D/L ratio of the sample of unknown age;
- D/Lm is the D/L ratio for a modern sample of the same species as D/Ls; and
- Mc is the slope.

Using the above formula, a total of twenty-eight aspartic ages calibrated by the radiocarbon method were determined to establish a geochronology for the Holocene sedimentary successions of Lake Illawarra. When examined within a lithostratigraphic framework, racemisation data permit the comparison of pre- and post-European sedimentation rates for Lake Illawarra (Figures 4a and 4b). For example, sedimentation rates using the top 50cm of a core collected from the central lagoon

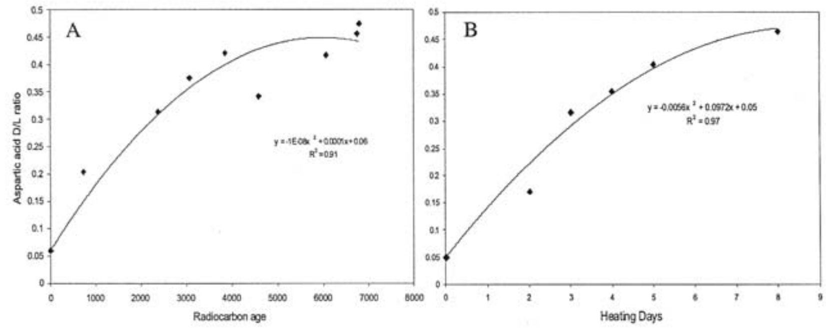

Figure 1a) A. trapezia *radiocarbon dating and aspartic acid dating techniques on the same sample.*
1b) Kinetic trend observed in heating experiment conducted on A. trapezia.

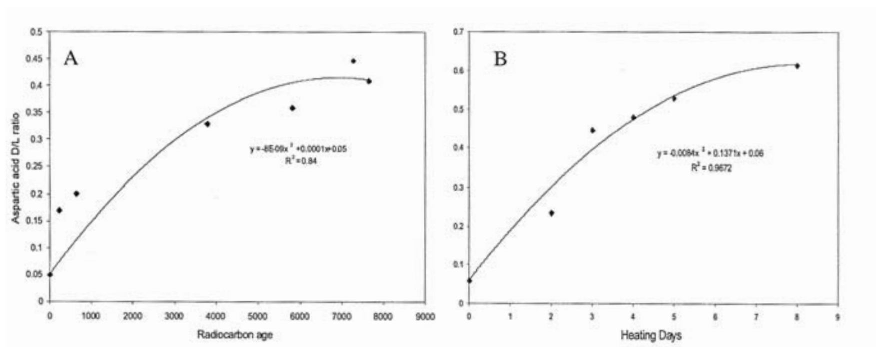

Figure 2a) N. trigonella *radiocarbon dating and aspartic acid dating techniques on the same sample.*
2b) Kinetic trend observed in heating experiment conducted on N. trigonella.

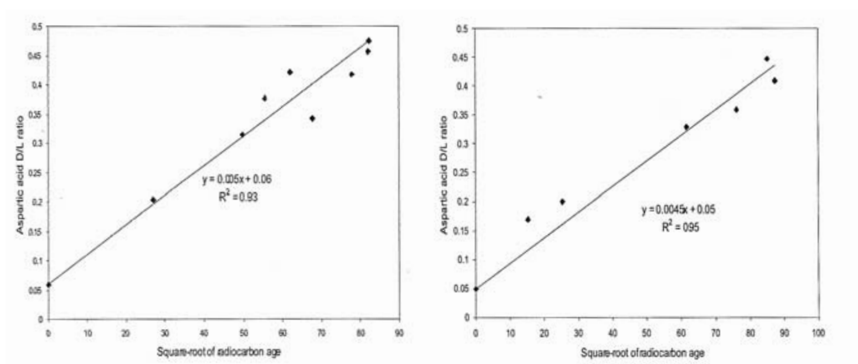

Figure 3. Square root of radiocarbon age plotted against D/L ratio of equivalent sample observed in a) Anadara trapezia*; and b)* Notospisula Trigonella.

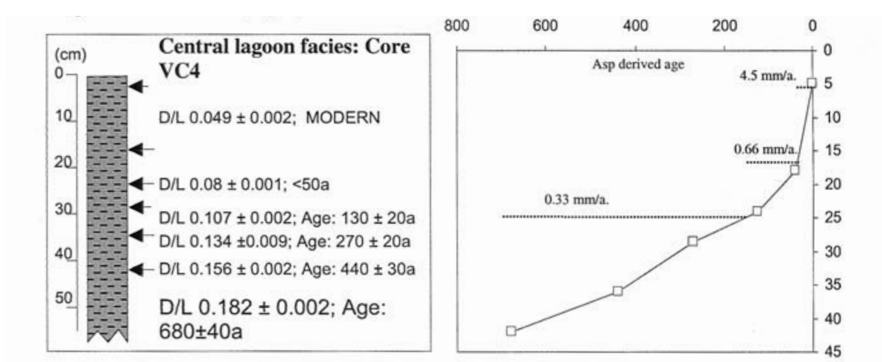

Figure 4. a) Asp D/L ratio and calculated age down core from central lagoon facies, Lake Illawarra.
b) sedimentation rates calculated for the central lagoonal facies.

of Lake Illawarra have been calculated using Asp-derived ages obtained from *in situ N. trigonella*. The results indicate that the rate of sedimentation was ca 0.33 mm/a for 500 years prior to European settlement. The period between 130 and ca 50 years BP, which corresponds with primary land clearing for agricultural development, shows an increase in sedimentation rate to 0.66 mm/a. The period from 50 years ago to the present, corresponding with an increase in urban and industrial development within the Lake Illawarra catchment, shows a dramatic increase in sedimentation rate to 4.5 mm/a, however, some of this can be attributed to lower compaction within the upper portion of the core (Figure 4).

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Palynological evidence for Plio-Pleistocene vegetation and climate cyclicity in upland Victoria, Australia

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Global Neogene climatic cooling was expressed in southeastern Australia by progressive reduction of formerly widespread mesotherm and microtherm rainforests, and their replacement by more drought- and fire-adapted, open-canopied vegetation (Kershaw et al. 1994; Macphail, 1997). These long-term trends of vegetation replacement accelerated with the relatively abrupt climatic shifts marking the initiation of the Quaternary. However, the response of vegetation to increasingly high amplitude orbital scale climatic cycles during the Late Pliocene–Early Pleistocene remains poorly understood. Pollen analysis of intermittently laminated sediments from a small volcanic palaeolake in upland southeastern Australia, the Stony Creek Basin, illustrates the orbital-scale response of both 'Tertiary' and 'Quaternary' floristic elements to the evolving climatic cyclicity of the late Cenozoic.

Eleven cycles in the 40m lacustrine record from Stony Creek Basin are indicated by variations in organic matter and pollen abundance. The primary pattern of change is alternation between presence and absence of Podocarpaceae-dominated rainforest, against a background of open-canopied sclerophyll forest dominated by *Eucalyptus*, Casuarinaceae and Cupressaceae (probably *Callitris*). The repetitive changes suggest pronounced differentiation of Plio-Pleistocene 'interglacial' and 'glacial' climatic stages, possibly related to 40 kyr variation in orbital obliquity.

A latest Pliocene–earliest Pleistocene age is supported by three independent lines of evidence. First, zircons recovered from inwashed basal sands, and from a pyroclastic horizon at 29m downcore give fission track ages of 1.99 ± 0.43 Ma and 1.93 ± 0.18 Ma, respectively. Second, palaeomagnetic analysis indicates that the sediments in the upper 25m of the core are of reversed polarity, and must predate the Brunhes/Matuyama polarity transition at 0.78 Ma. A zone of normal polarity below 25m is tentatively attributed, consistent with the 1–sigma error of fission track ages, to the Olduvai subchron, the upper boundary of which has an age of 1.78 Ma (Lourens et al., 1996). Third, the pollen assemblages are generally consistent with regional palynostratigraphies through the presence of pollen types for which the latest Pliocene represents either their first (open forest taxa including *Pomaderris*, *Plantago*, and *Pimelea*) or last (rainforest taxa including *Beauprea*, *Ilex*, *Lophosoria*) regional appearance (Stover and Partridge, 1973; Macphail, 1997, 1999). It is therefore concluded that the record embraces the final two climate cycles of the Pliocene, and the initial seven or eight cycles of the Pleistocene.

Rainforest taxa represented at Stony Creek Basin are now confined, in Australia, to relictual stands near the east coast and in Tasmania (e.g. *Symplocos*, *Quintinia*, *Macaranga*, Cunoniaceae, Araucariaceae, *Podocarpus*, *Phyllocladus*) or are extinct/very restricted Australia wide (e.g. *Ilex*, *Dacrydium*, *Dacrycarpus*, *Beauprea*, *Podosporites* cf. *microsaccatus* [Podocarpaceae], *Dilwynites* cf. *granulatus* =*Wollemia*? [Araucariaceae]). Many of these rainforest taxa were components of floras of both New Zealand and Australia during the Miocene, but these floras diverged during the late Neogene apparently in response to rapid uplift and cooling of the former landmass, and increasing seasonal aridity of the latter (Martin, 1982; Lee et al., 2001). The Early Pleistocene presence in upland southern Australia of many of these shared Miocene rainforest genera indicates that modern floristic divergence of the two landmasses was not completed by the Early Pleistocene.

Nothofagus pollen is virtually absent during the c. 10 consecutive rainforest expansions at Stony Creek Basin, suggesting that this genus played little or no role in western Victorian Plio-Pleistocene rainforest. This seems perplexing, since rainforests in southern Victoria and Tasmania today are almost exclusively dominated by *Nothofagus cunninghamii* (subgenus Lophozonia) (Read and Brown, 1996). However, modern New Zealand conifer-angiosperm forests dominated by, e.g., *Podocarpus*, *Dacrydium*, *Dacrycarpus*, *Weinmannia* and *Quintinia* form temperate rainforest communities largely lacking *Nothofagus* which may provide approximate analogues for Stony Creek Basin rainforests. These communities dominate lowlands of both North and South Islands, largely restricting species-poor *Nothofagus*-dominated forests to the coldest montane and especially southern environments (Ogden and Stewart, 1995). Thus the absence of *Nothofagus* from Stony Creek Basin may reflect climatic segregation of formerly more diverse southeast Australian rainforest types.

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FORTHCOMING CONFERENCES AND MEETINGS

Paleoclimate Proxy Data for Reconstructing Holocene Environments of West Asia

Held at the 4th International Congress on the Archaeology of the Ancient Near East, Berlin, April 1–7, 2004.

This workshop aims to synthesize all proxy data retrieved from ice, lake, marine and speleothem cores across West Asia and adjacent regions to establish a synoptic sequence of natural Holocene climate stages defined by their precipitation, temperature, seasonality and other qualities. This synthesis would provide a base-line for examining anthropogenic environmental alterations during the period 12–3 kaBP. One volume of contributions and syntheses will be published by April 2005.

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Interhemispheric Records of Paleoclimate Change: Low Latitude Influences on the High Latitudes, or the Other Way Around

Topical Session 98 at the 2003 Geological Society of America Meeting, Seattle. November 2–5, 2003.

Emerging evidence and modeling now suggest the tropics may drive the climate system on a variety of time scales. Is this correct? This session invites evolving ideas aimed at pole-equator-pole data comparisons and/or modeling of Quaternary oceanographic and terrestrial proxy records.

Further information:
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Late Quaternary ecosystem tropical dynamics: a sensitive tool for unravelling climate, ecological and human impacts

International Palynology Congress, Granada. July 2004.

The aim of this session is to emphasize the importance of tropical palaeoecological records from South America, Asia/Australia and Africa as being highly sensitive archives of change. We intend to achieve this broad aim on three fronts by focusing the session into the following areas: ecosystem change, human dimensions and the future

Conveners: Robert Marchant: marchanr@tcd.ie and Hermann Behling

Climate change: a paleo-ecological perspective

A symposium at the next Southern Connections meeting in Cape Town. January 19–23, 2004.

In the past there has been a strong emphasis on inter-hemispheric comparisons between paleo-climate records from northern and southern latitudes. The aim of this symposium is to examine the nature and timing of past climate change as reflected in paleo-ecological records from different geographical regions within the southern hemisphere. The presentations should encompass a wide range of topics that might include: Dynamics of the Southern Westerlies; abrupt climate change events in the Southern Hemisphere; comparison between marine and terrestrial paleo-ecological records of past climate; and the problems of decoupling climate change from human impact in the paleo-ecological records. The meeting will provide a unique opportunity to compare paleo-ecological records from Africa, Australia, New Zealand, South America and the southern oceanic islands and for participants to interact with other scholars from these regions.

If you are interested in contributing, either a poster or an oral presentation, please provide a title, preferred method of delivery, and abstract to the conference secretariat (via email at sc2004@botzoo.uct.ac.za) by NO LATER than 31 August 2003. See the conference web page for further details. Please also send this information to Simon.Haberle@anu.edu.au.

Given that there are limited slots for oral presentations, the poster session will be a significant part of the conference.

Convenor: Simon Haberle: Simon.Haberle@anu.edu.au

The Measurement and Origin of Biodiversity

A one-day meeting to be held in association with the Australasian Association of Paleontologists / Geological Society of New Zealand annual conference, Dunedin, New Zealand (December 5, 2003).

Understanding the origin, history and controls of biodiversity remains one of the primary goals of paleontology and biology. The measurement and interpretation of biodiversity data, however, is fraught with problems. In this meeting we will bring together paleontologists and biologists to explore some of the perplexing questions surrounding biodiversity.

Further information:
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Advances in Regolith 2003

The Cooperative Research Centre for Landscape Environments and Mineral Exploration is hosting three regional regolith symposia in Australia in late 2003:Central Symposium–Adelaide University, November 13–14, 2003; Eastern Symposium–The Australian National University, November 19–21, 2003; and Western Symposium–Curtin University of Technology, November 24–25, 2003.

Each symposium will address the strategic themes of CRC LEME, which include:

- Improving our understanding of regolith processes and landscape evolution;
- Making exploration geochemistry work through cover;
- Developing geophysical techniques to interpret regolith architecture;
- Using regolith knowledge to enhance prospectivity in geological regions;
- Developing methods to map and predict salinity with outcomes linked to mitigation and remediation.

Additional special themes will also be addressed at each different node including:

- Biological Factors in Regolith Formation (ANU);
- Acid Sulphate and Saline Regolith (Adelaide University);
- Geophysical Imaging and Dating of the Regolith (Curtin University of Technology).

This invitation extends to all regolith or regolith-related discipline researchers in Australasia. Invitees include Honours and post-graduate research students and also professionals working in regolith research within universities, state and federal research institutions, retirees and the general regolith geoscience community. Presenters do not necessarily have to be affiliates of CRC LEME.

Registrants are invited, in the first instance, to attend the closest symposium unless they wish to present in one of the special themes (above). Abstracts for all three symposia will be published as a single, fully refereed CRC LEME Report, 'Advances in Regolith 2003'.

Abstract submissions close 31 August, registration closes 31 October.

Further information: http://crcleme.org.au/.

The 34th Annual International Arctic Workshop

At the Institute of Arctic and Alpine Research (INSTAAR), University of Colorado at Boulder, March 11–13, 2004.

The workshop web site is http://instaar.colorado.edu/meetings/AW2004/ (note that 'AW' is capitalized).

Submission of abstracts through our web site will begin before December 15th, 2003. Deadline for submissions will be February 22nd, 2004.

Further information: ArcticWS@colorado.edu

QUATERNARY AUSTRALASIA

Material for the next issue should reach the editor by **31st October 2003** (research papers) and **30th November 2003** (all other material).

The Australasian Quaternary Association (AQUA) is an informal grouping of people interested in the manifold phenomena of the Quaternary. It seeks to encourage research by younger workers in particular, to promote scientific communication between Australia and New Zealand, and to inform members of current research and publications. It holds biennial meetings and publishes the journal *Quaternary Australasia* twice a year. *Quaternary Australasia* is edited by Kale Sniderman. The annual subscription is A$25 or A$15 for students, unemployed or retired persons. To apply for membership please contact Janelle Stevenson (address below). Members joining after September gain membership for the following year. Existing members will be sent a reminder in December.

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Australian Quaternary Association

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