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Quaternary AUSTRALASIA

The Quaternary Sub-Era? Southern Hemisphere Deserts

Yukon Tephrochronology & Volcanism Greenhouse2005

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COVER *Browningia candelaris* in the Atacama. See Pauline English's report on the Southern Deserts conference, p. 19. Photo: P. English.

BELOW 2.74 m (9 ft) Mammoth tusk retrieved from gold-bearing gravels at Last Chance Creek, Klondike Goldfields. The purplish exterior colour of the tusk is vivianite. Note the faceted point of the tusk – a result of abrasion from ground browsing. See Brent Alloway's report on Yukon tephrochronology, p. 16. Photo: B. Alloway.

EDITORIAL

This issue includes an update, by Brad Pillans, on discussion concerning the status of the Quaternary within the geological timescale. Quaternarists may be heartened by Brad's report of recent agreement within the International Commission on Stratigraphy to formally enshrine the Quaternary within the timescale, although, not without some irony, at the unexpected level of a sub-Era. This would elevate the Quaternary, at least in a formal sense, higher than the Period status that has long been sought by many of those working at the top of the geological column. In addition, ratification of the Quaternary as a sub-Era seems to require, for symmetry's sake, exhumation of that old Francophile concept, the Tertiary. Insofar as ratification of the ICS proposal by the IUGS depends on its reception by the Quaternary community, the fate of the Tertiary (I must admit I find myself visualising the deceased 'third' era as a resurrected horror-flick zombie wandering the Earth, slightly deranged after blindly rising from its grave, Palaeogene regolith still lodged in its eyelashes, Neogene mud crumbling off its shoulders) currently appears to rest, in a strange and unprecedented ironic twist, in the hands of Quaternarists. INQUA president John Clague's letter soliciting opinion from Quaternarists, INQUA president John Clague's letter soliciting opinion from Quaternarists, circulated by email in late 2005, is reproduced in full here as a part of the story, even though the deadline for submissions has apparently passed.

Global warming gets more than a look in here, with a joint review of recent books on the topic by Tim Flannery and Barrie Pittock, and a report from Melbourne's Greenhouse2005 conference. Also reviewed is a new edition of Twidale and Campbell's *Australian Landforms*. Paul Hesse, whom I must shout a couple of drinks next time I see him, examines the scholarly roots of Australian Quaternary science, while Simon Haberle reviews recent Australian Research Council funding results. Pretty pictures accompany conference trips in the Atacama and the Yukon. Apologies for the late appearance of this issue, the production of which coincided squarely with my shifting house! Next issue, expect to see a report from the INQUA 2007 committee.

Cordially,
Kale Sniderman

PRESIDENT'S PEN

Dear Friends of the Quaternary,

Last issue I promised this pen would be written from a less exotic location than the Galapagos Islands. To my own surprise I have not succeeded. I am writing this from my new office at the Sydney Catchment Authority in Penrith. Now Penrith, of course, will be the new geographical centre of Sydney by 2050. At present it is the home of Panthers entertainment, so it already is the centre of the universe when it comes to poker machines. Penrith is also situated on the banks (fluvial terraces) of the Nepean River, which flows slowly at the bottom of the Lapstone monocline. My new job is exciting, as I have to deal with climate variability and the effects of extreme events (such as landslides and earthquakes) on water quantity and quality in Sydney's vast catchment area (16,000 km^2, which is roughly half the size of my country of origin).

The main news is that the organising committee of the Cairns INQUA 2007 Conference has met several times since August 2005. Good progress is underway in organising the framework for this exciting conference.

The ARC funding round of October 2005 saw some interesting success stories for Quaternary studies; congratulations to all who were successful. It was good to see some large grants went to Quaternary research.

The news from the Federation of Australian Science and Technology Societies public forum at the last board meeting in the Australian Museum was all about the Research Quality Framework which will hit the academic world next year. They will also organise another Science meets parliament on 28th February and 1st of March 2006.

All the best for 2006.
Henk Heijnis

The Quaternary Sub-Era?

Brad Pillans
President, INQUA Stratigraphy & Chronology Commission

To facilitate international communication, the rock record of the earth is divided into standardized global chronostratigraphic units that make up the international Geological Time Scale (GTS), managed by the International Commission on Stratigraphy (ICS). No geological time scale can be final, and the GTS is continually being refined as new data become available. The latest iteration is GTS2004 (Gradstein *et al*. 2004), which follows earlier iterations such as GTS1989 (Harland *et al*. 1990) and GTS1982 (Harland *et al*. 1982). The next iteration is planned to be GTS2008. Chronostratigraphic subdivisions of the Cenozoic Erathem as depicted in recent and planned versions of the GTS are shown in Figure 1. Significant changes since GTS1982 include the definition of the Gelasian Stage in the uppermost Pliocene, and extension of the Neogene System upwards to the present.

Note that formal subdivisions of the Phanerozoic part of the GTS are defined by their lower boundaries at Global Stratotype Sections and Points (GSSPs), often referred to as golden spikes. Since a GSSP automatically defines the upper boundary of the underlying unit, the possibility of overlap between adjacent units is thereby eliminated. The designation of a GSSP is a necessary requirement for formally defining any chronostratigraphic unit. For example, the GSSP for the base of the Pleistocene Series (= top of Pliocene Series) is located at the top of sap-ropel layer 'e' in the Vrica section, 4 km south of Crotone in Calabria, southern Italy (Aguirre and Pasini 1985), with an astronomically calibrated age of 1.806 Ma (Lourens *et al*. 1996).

Publication of the most recent iteration of the Geological Time Scale (GTS2004) by Gradstein *et al*. (2004) was not good news for the Quaternary – in GTS2004 the Quaternary was designated as an informal climatostratigraphic unit, rather than as a formal chronostratigraphic unit. Many Quaternarists were alarmed by the apparent stratigraphic demise of the term "Quaternary". Would it be dead and buried along with their favourite Quaternary journals and societies? Indeed, would AQUA and INQUA become irrelevant acronyms for lack of a formal Quaternary unit in the international geological time scale?

Suggestions for "saving" the Quaternary were made by Gibbard *et al* (2004), Pillans and Naish (2004) and Aubry *et al*. (2005), and the various options were extensively discussed by INQUA members. A significant outcome was that a majority of Quaternary scientists favoured a definition of the Quaternary with its base at ~2.6 Ma to encompass the time interval during which (1) the Earth's climate has been strongly influenced by bi-polar glaciation, and (2) the genus *Homo* first appeared and evolved (see Pillans and Naish 2004). Previously, the base of the Quaternary had been tied to the base of the Pleistocene at ~1.8 Ma (see GTS 1982/1989 in Fig 1), but this definition was never entirely accepted by the Quaternary community, nor was it formally ratified by ICS. With formal recognition of the Gelasian Stage (Rio *et al*. 1998) as a new, uppermost stage of the Pliocene, with its base at ~2.6 Ma, it seemed logical to investigate a new, formal definition which would use the base of the Gelasian to define the base of the Quaternary.

It was obvious from the outset (to me, at least) that any progress in "saving" and redefining the Quaternary needed to be a close collaborative effort between INQUA and ICS. Thus, in August 2004 I made a recommendation to the International Geological Congress in Florence that a joint INQUA-ICS Task Force be set up to define the Quaternary as a formal unit of the GTS. The recommendation was accepted, the task force was duly convened, and delivered its verdict(s) in late August 2005. In September 2005, having reviewed the findings of the task force, ICS voted to define the Quaternary as a Sub-Era/Sub-Erathem, with its base defined by the GSSP for the Gelasian Stage (~2.6 Ma). INQUA must now decide whether to accept this definition, and has asked its members for their opinions (see below), prior to making a decision at the INQUA executive meeting that I will attend in late February 2006. Should INQUA resolve to accept the ICS definition, then the Quaternary Sub-Era will be immediately ratified by IUGS. If not, the Quaternary will remain in limbo, with no immediate prospect (if ever) of being formally defined as a chronostratigraphic unit of the GTS.

AQUA members should read the document (below) from INQUA president, John Clague. My experience in such polls is that those who disagree with a proposal are usually the most vocal. I therefore urge all of you to email John and state your acceptance of the ICS proposal to formally define the Quaternary as a Sub-Era, with base defined by the Gelasian GSSP (~2.6 Ma).

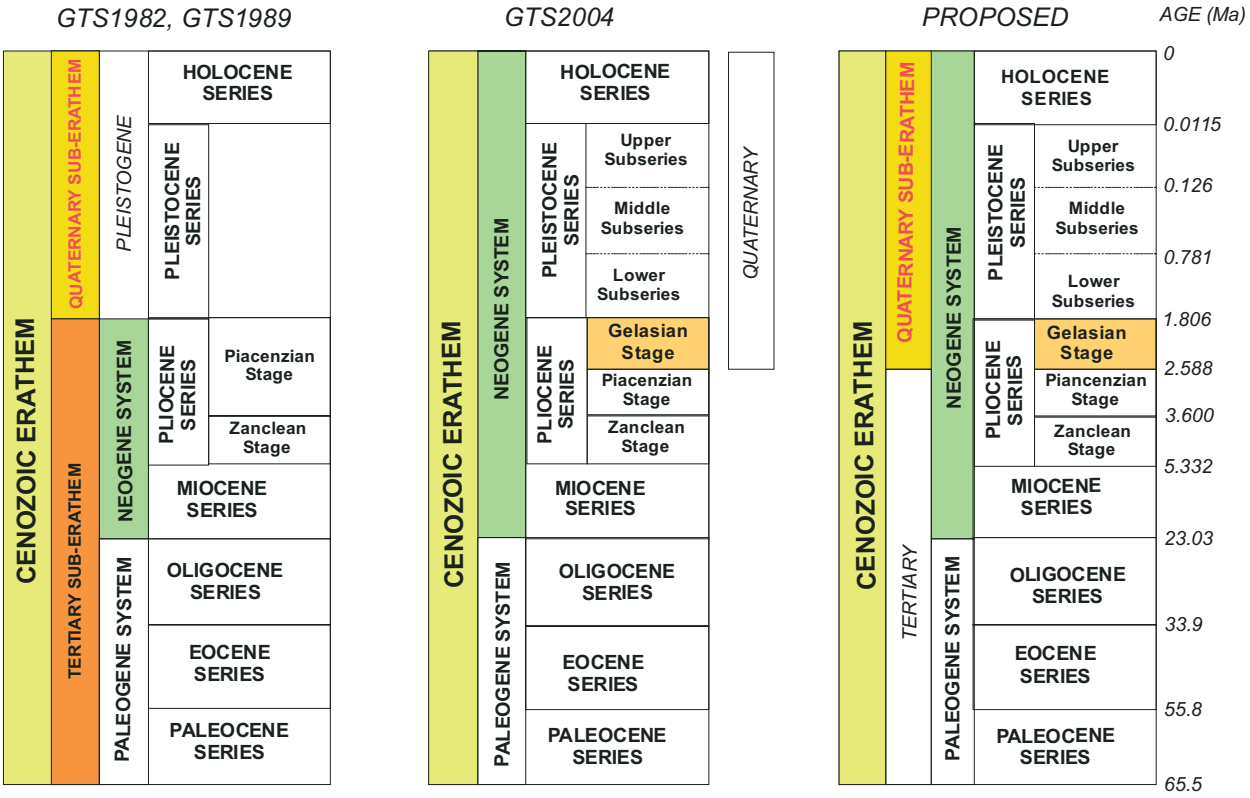

Figure 1 The evolving chronostratigraphic subdivision of the Cenozoic according to recent and proposed iterations of the international Geological Time Scale (GTS). Sources: GTS1982 (Harland *et al.* 1982), GTS1989 (Harland *et al.* 1990), GTS2004 (Gradstein *et al.* 2004). For simplicity, stages of pre-Pliocene Series are not shown.

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Status of the Quaternary:
YOUR OPINION SOUGHT

John Clague
President, INQUA

The International Commission on Stratigraphy (ICS), a body of the International Union of Geological Sciences (IUGS), is in the process of standardizing the Geological Time Scale, a task to be completed before the next International Geological Congress in 2008.

Quaternary task force

In 1985, with the placement of the base of the Pleistocene GSSP, "*The subject of defining the boundary between the Pliocene and Pleistocene was isolated from other more or less related problems, such as the pending definition of the Calabrian, and the status of the Quaternary within the chronostratigraphic scale.*" (E. Aguirre and G. Pasini, 1985, The Pliocene-Pleistocene Boundary, *Episodes* 8: 116–120). For various reasons, the "*pending definition ... and status of the Quaternary*" was never formally resolved, nor submitted to ICS/IUGS for consideration or ratification.

Following the International Geological Congress in 2004 in Florence, INQUA and ICS set up a task force to consider the issue. The task force was charged with making a recommendation, within one year, to ICS on the definition and possible rank of the Quaternary in the Geological Time Scale. It issued its report before a meeting of ICS in Leuven, Belgium, in September 2005. Its recommendation to ICS was as follows:

1. That the Quaternary should be recognized as a formal chronostratigraphic/ geochronological unit.
2. That the lower boundary of the Quaternary coincide with the base of the Gelasian Stage (2.6 Ma) and thus be defined by the Gelasian GSSP.
3. That the Quaternary will have the rank of either:
   a. System/Period at the top of the Neogene System/Period, with its lower boundary marking the top of a shortened Neogene, or
   b. Sub-Erathem/Sub-Era correlative with the upper part of the Neogene System/Period

ICS decision

Following extended discussion at Leuven, the ICS voting membership unanimously voted, by a show of hands, that the Quaternary be recognized as a formal chronostratigraphic/geochronologic unit with a lower boundary coinciding with the base of the Gelasian Stage and defined by the Gelasian GSSP. The voting membership considered several options for the rank of the Quaternary, and voted on the options by a show of hands. Only one option received a majority: that the Quaternary have the rank of Sub-erathem/Sub-era. Subsequently, a written ballot was held on this single issue, i.e. whether or not the Quaternary should have the rank of Sub-Erathem/Sub-Era. The voting membership consisted of the executive officers of ICS and the chairs of the ICS subcommissions. The final vote on the Sub-Erathem/Sub-Era option was:

Yes	12 votes
No	5 votes
Abstain	1 vote

The result is that the lower boundary of the Quaternary would be defined at the base of the Gelasian Stage, at 2.6 Ma. Through an early polling of the Quaternary community, INQUA found that the vast majority of Quaternary scientists favour a 2.6 Ma boundary over the current 1.8 Ma one. A further result is that the Quaternary, although firmly formalized as a chronostratigraphic/geochronologic unit, would not be a System/Period above the Neogene. The Neogene would extend from the base of the Miocene to the present.

What now?

INQUA informed ICS, prior to the Leuven meeting, that it would consult the Quaternary community prior to deciding whether or not to support the new ICS position on the Quaternary. The INQUA Executive Committee is thus seeking your opinion. Please let us know whether the ICS proposal is acceptable to you or not? Below, I summarize this option and what the Executive Committee considers to be its pros and cons.

Definition of the Quaternary

The Quaternary is a Sub-Erathem/Sub-Era correlative with the upper part of the Neogene System/Period and with a lower boundary coincident with the base of the Gelasian Stage (2.6 Ma) (Fig. 1).

PROS:

- Quaternary is a formal chronostratigraphic/ geochronologic unit, with a standardized definition and would be displayed on the international geological time scale.
- Base of the Quaternary is pinned at 2.6 Ma.

ICS has accepted this option.

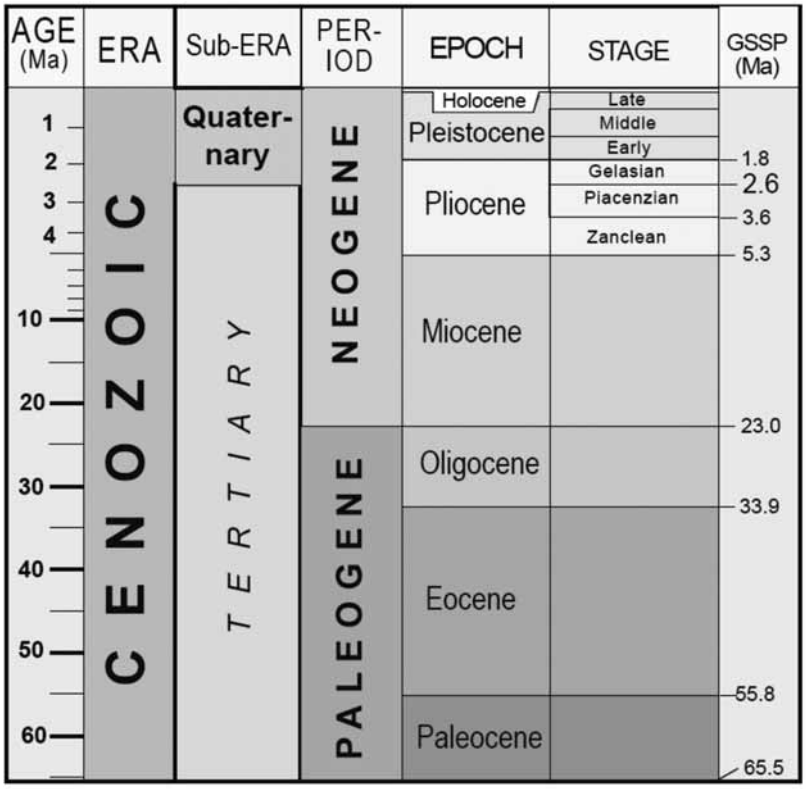


Figure 1 Subdivisions of the Cenozoic Era proposed by ICS, with the Quaternary defined as a Sub-erathem/Sub-era with a base at 2.6 Ma.

CONS:

- The Quaternary is not a Period/System.
- The base of the Quaternary and that of the Pleistocene Epoch are not the same (the base of the Pleistocene remains at 1.8 Ma; the base of the Quaternary becomes 2.6 Ma).

Two other options have been discussed

Option 2: The Quaternary is a Period/System above the Neogene, comprising the Pleistocene and Holocene epochs with a base at the base of the Gelasian Stage (2.6 Ma).

Option 3: Same as Option 2 except that the lower boundary of the Quaternary coincides with the base of the Pleistocene (1.8 Ma). Many Quaternary researchers consider this option the status quo.

ICS has made it clear that it will not accept option 2, and it likely will not accept option 3. Thus, unless IUGS were to side with INQUA against its own commission, and could convince ICS to accept the Quaternary as a Period, the term will not have a standardized definition or formal ratified status on the Geological Time Scale. INQUA might lobby IUGS to reject ICS's revised time scale, with the hope that it would instruct ICS to accept Option 2, but it seems unlikely that it would interfere in this manner with one of its commissions.

What would be the consequences if the "Quaternary" was not formally included in the Geological Time Scale? The term would continue to be used, albeit informally, much as the "Precambrian" is used today. However, the stature of the "Quaternary", and more importantly our field of study, likely would be diminished, with uncertain future consequences. It might be difficult to have the Quaternary added to the Geological Time Scale at a later date.

Further thoughts on this issue are welcome and can be emailed to John Clague: *jclague@sfu.ca*

Trends in the ARC funding 2002–2005

Simon Haberle

2005 has been a year of surprises from the research funding point of view. A number of one-off schemes and new funding sources have been announced, many at very short notice, to the academic community. The Research Networks, Center of Excellence round, followed by New Initiative Schemes through the ARC produced frantic attempts to put together research teams that might fit the perceived vision of government for future research directions. Much of this activity went unrewarded, though the process itself may have galvanized potential future directions in the minds of those who took part in these bids. The current Commonwealth Environment Research Facility fund through the Department of Environment and Heritage represents a new approach to dividing up government research money and may well signal a future devolving of control of the research dollar from ARC to other government areas. Whatever the case, it is likely that the next year will bring further unexpected opportunities.

Below is an outline of the recent successful grants in the latest ARC Discovery and Linkage round. Congratulations to all those who were successful. These included four APD/QEII fellowships so this is excellent for early career researchers. The 22 successful grants included 19 Discovery plus two Linkage and one Linkage Infrastructure grant. As in previous years I've compared the results of this year's round with previous three years and there are encouraging signs of continued ARC support for the Quaternary sciences (including archaeology).

In general the trends are:

1. total number of grants is similar to the last two years,
2. funding level of around $6 million for Discovery grants in Quaternary Sciences has been maintained for this years grant round,
3. components of archaeology continue to feature strongly in Quaternary Science applications,
4. of the nine successful archaeology grants only two were for Australian based research (similar to other years), and
5. there is a slight drop in the number of institutions receiving funding (13 in 2003–2004 and 10 in 2005).

This last point, while only a minor drop, may prove to be significant over the longer term, particularly with the forthcoming Research Quality assessment being introduced in 2007. One possible consequence may be the centralizing of expertise in particular disciplines in fewer universities, which may see a further reduction in the number of institutions able to attract ARC funding. Alternatively, a multi-disciplinary research area such as Quaternary Sciences may be able to avoid this through strengthening inter-institutional collaborations and taking advantage of existing links.

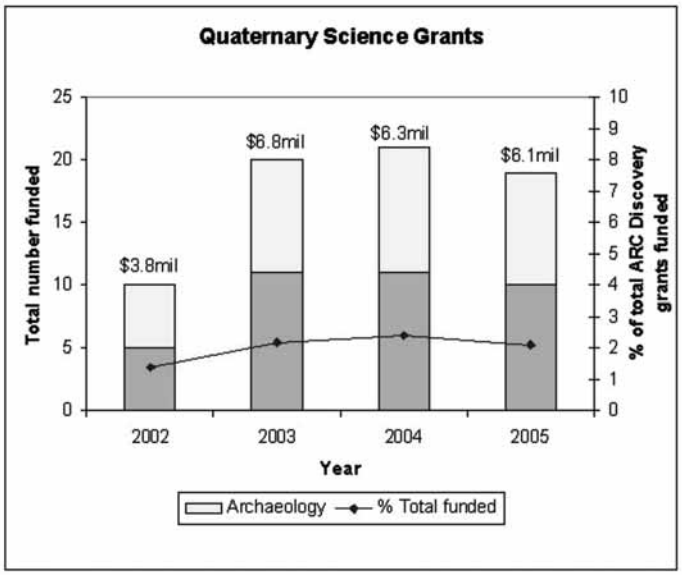


Figure 1. Quaternary-related ARC Discovery Grants 2002–2005. The bar graphs show total number of Quaternary-related grants funded, the line shows % this represents of total grants allocated in that year, and a figure for the total funding in million dollars allocated to Quaternary-related projects appears above each year. Data from the ARC annual reports 2002–2005: *http://www.arc.gov.au/funded_grants/selection.htm*

Finally, there has been a recent change in personnel in the ARC College of Experts (the body of experts who decide on ARC rankings). The new board will commence in 2006 and we will have different people in the final assessment of our grant applications than in the previous 3 years. It is not clear to me whether the strength of personality of advocates for any given field would necessarily play a role in determining how many grants got over the finish line. Whether or not this will have an impact on how the Quaternary sciences fare in the next round, only time will tell … and we'll be watching …

Succesful ARC grants for 2005

Discovery Grants

ARCHAEOLOGY AND PREHISTORY / ANTHROPOLOGY

CI's: Prof AJ Anderson; Dr K Szabo; Dr E Conte
The origins of human colonization in East Polynesia and their relevance to maritime migration
The Australian National University
2006: $65,000; 2007: $65,000; 2008: $65,000
Project Summary The IndoPacific is a world of islands, including Australia, which was colonized during prehistory in several phases of migration, the last and longest of which was in East Polynesia. Extensive excavation of a large, waterlogged archaeological site of this era in French Polynesia will provide a better understanding of the period, society and external relationships of the early migrants, and of the processes of prehistoric maritime migration which link Australian peoples to those of our neighbours across the Pacific and Indian Oceans.

CI's: Dr FD Bulbeck; Dr MF Oxenham
The Flores hobbit Homo floresiensis or microcephalic eastern Indonesian?
The Australian National University
2006: $40,000
Project Summary The hobbit is so controversial as it implies that a tiny hominin with a miniature brain coexisted for 30,000 years with modern humans in our region. This would have immense, fundamental implications for understanding the human colonisation of our region and the role of brain size in human evolution. Our research will determine whether the alternative explanation of microcephalic pathology is viable. If so the hobbit would still be of unique signficance as the only known microcephalic huntergatherer who had survived to adulthood. The role of Australian scientists in spearheading the hobbit discovery places a high priority on resolving the debate objectively.

CI's: Dr RF Cosgrove; Dr C Shen; Dr H Lu
APD: Dr S Wang
Chinese Middle to Late Pleistocene hominid behaviour: exploring cultural variability through time and space
La Trobe University
2006: $156,000; 2007: $82,000; 2008: $125,000
Project Summary This research will contribute to the understanding of the spread of our species out of Africa 2 million years ago into East Asia. It examines the range of hominid behaviours and ecological circumstances that led to the successful colonisation of China by Homo erectus. It also addresses the vexed question of the relationship between H. erectus and H. sapiens. Did the latter evolve in situ from their antecedents as some suggest, or did H. sapiens replace H. erectus, in the great diaspora from Africa 120,000 years ago?

APD: Dr K da Costa
Drawing the line: the archaeology of Roman provincial borders in Late Antique Palaestina and Arabia (AD 250 –650)
The University of Sydney
2006: $109,000; 2007: $74,000; 2008: $84,000; 2009: $66,000
Project Summary This project, using archaeological evidence from Jordan, will for the first time accurately establish the boundaries of provinces in the Roman Empire. By linking Australia and the Middle East in international scholarly research dealing with our common cultural heritage, it will increase our mutual understanding. The examination of very longterm trends in an ancient system which dealt with a complex, multicultural population will provide much needed comparative illustrations for the current national debate on the nature and security of Australian borders. It will also provide evidence of longterm economic change and its political consequences.

APD: Dr TP Denham
Unearthing the roots of agriculture: multidisciplinary investigations of Pleistocene and Holocene plant exploitation in Eastern Highlands Province, Papua New Guinea
Monash University
2006: $140,000; 2007: $145,000; 2008: $145,000
Project Summary The Project will foster greater communication, public understanding and research links between Australia and Papua New Guinea. The Project will also provide archaeological training for students at Australian universities and students and practitioners in Papua New Guinea. The research seeks to understand the development of societies and subsistence practices, particularly plant exploitation and agriculture, in New Guinea from the Pleistocene to the present. The research will chart longterm human environment relations in New Guinea, which are central to under-standing the sustainability of food production and the maintenance of biodiversity in the Australasian region.

CI: Dr AS Fairbairn
Plant use at the dawn of agriculture in central Anatolia
The Australian National University
2006: $20,000; 2007: $20,000
Project Summary The project will increase collaboration with researchers in the UK, and Turkish archaeological authorities. It will refine our understanding of the process, rate and direction of agricultural origins in Western Asia and improve Australia's profile in origins of agriculture research. It will increase Australia's knowledge base about other regions and help to consolidate and promote archaeobotany/archaeological science in Australia's research community.

CI's: A/Prof PC Memmott; Dr SG Ulm; A/Prof IA Lilley; A/Prof ND Evans; Dr EC Stock; A/Prof NG White; Dr SM van Holst Pellekaan; Prof DS Trigger; Dr RP Robins
Isolation, Insularity and Change in Island Populations an Interdisciplinary Study of Aboriginal Cultural Patterns in the Gulf of Carpentaria
The University of Queensland
2006: $90,000; 2007: $90,000; 2008: $90,000; 2009: $55,000; 2010: $40,000
Project Summary The project's national benefits centre on its contribution to safeguarding Australia and to an environmentally sustainable Australia. The participation of northern Indigenous people is critical to border protection policies and procedures. This project will help revitalise the Carpentaria Land Council's Aboriginal Rangers scheme, which has a potential role in safeguarding the nation's northern approaches, including combating feral plant and animal importation, Coastwatch surveillance and marine habitat protection. The geological research on sea level and climatic history in the Gulf of Carpentaria and associated coastal geomorphological impacts will contribute to predictive models on global warming and its consequences (sea level rise).

APD: Mr M Moore
How Do Stone Tools Reflect Cognition Among the First Australians and their Precursors?
The University of New England
2006: $85,000; 2007: $78,000; 2008: $78,000
Project Summary The popularity of the Indonesian 'hobbit' (Homo floresiensis) discovery provides an ideal platform for interpreting Australasian prehistory to a wider community. This project explores the arrival of modern humans in Indonesia, their interaction with 'hobbits', and the colonisation of Australia by comparing the different ways these hominins made stone tools. Although research indicates a significant level of behavioural unity in our genus, 'hobbits' were not like us. 'Us' refers, of course, to modern humans, and hence this research is of global relevance. By applying a 'design space' model to toolmaking in the past, this project will demonstrate that the earliest trends in technology apply equally to human groups throughout the world.

CI's: Prof FB Sear; Mr AE Hutson; Dr HM Goldsworthy
Technological Advances in Largescale Roman Concrete Buildings during the 2nd and 1st centuries BC
The University of Melbourne
2006: $70,000; 2007: $30,000; 2008: $40,000
Project Summary How were the Romans able to build monuments which are still standing after 2,000 years? Skills to achieve this were clearly not developed overnight. A multidisciplinary team from the University of Melbourne has identified the 1st century BC as a time of tremendous technological change in Roman architecture. Was it that the Romans used a technologically advanced type of concrete? Was it that they had perfected the structural design of vaults and domes? Was it simply their organisational ability or the enormous wealth which flowed from their vast Empire? A team of experienced archaeologists, architects and engineers seeks to answer these questions by survey and material analysis of a number of key Roman monuments.

ATMOSPHERIC SCIENCES

CI's: Dr MK Gagan; Dr WS Hantoro; Dr DH Natawidjaja; Dr JM Lough; Dr G Meyers; Prof Z Liu; Prof K Sieh
The Indian Ocean Dipole, Australasian drought, and the greatearthquake cycle: Longterm perspectives for improved prediction
The Australian National University
2006: $260,000; 2007: $190,000; 2008:$180,000; 2009: $183,000; 2010: $203,000
Project Summary The protracted drought across Australia and Boxing Day 2004 earthquake in Sumatra defied prediction, and are causing incalculable environmental, economic, and social harm. Knowledge of past climate extremes will enhance our ability to predict climate change, and alleviate adverse affects for Australasian nations who missout in the future redistribution of lifegiving moisture. Insights into the great earthquake cycle will help fulfil Australia's responsibility to predict tsunamis, for the benefit of nations fringing Australasian seismotectonic zones. Development of improved techniques in palaeoclimatology, palaeoclimate modelling, and palaeoseismology will provide new collaborations and opportunities for research, training, and education.

CI's: Dr MK Gagan; Dr J Zhao; Dr RN Drysdale; Dr WS Hantoro; Dr GA Schmidt
Monsoon extremes, environmental shifts, and catastrophic volcanic eruptions: quantifying impacts on the early human history of southern Australasia
The Australian National University
2006: $245,000; 2007: $100,000; 2008: $100,000
Project Summary The coincidence of a long, diverse Australasian human history with Earth's greatest climate systems presents the Australian and Indonesian communities with unrivalled opportunities for scientific discovery. Our study will improve understanding of global climate change, environmental shifts, volcanic catastrophes, and their role in early human dispersal, and extinction, in Australasia. The significance of the results will extend to the modern world, where human behaviour modifies, and is modified by, climate and environment. Integration of research strengths in Australia and Indonesia will contribute to an improved bilateral relationship in science, education, and training, and engage the public in the excitement of scientific discovery.

CI's: Dr CS Turney; Dr SG Haberle
Testing the hypothesis of synchronous interhemispheric climatic change during the Last Termination (20,000 –10,000 years ago)
University of Wollongong
2006: $169,000; 2007: $110,000; 2008: $100,000
Project Summary The results generated in this project will provide a greater understanding of the sensitivity of the Australasian region to a range of different climatic conditions (far beyond that recorded in historical datasets). Focussing on climate at the end of the last ice age (20,00010,000 years ago) we will investigate the timing, rate and magnitude of change in the Australasian region and test whether the variability was in phase with other records from the mid and high latitudes of the Southern and Northern Hemisphere. The results will provide a considerably improved context for understanding present and future climate change in Australia.

CI: A/Prof CD Woodroffe
Variability in El Niño frequency and intensity over the past 4000 years
University of Wollongong
2006: $45,000; 2007: $35,000; 2008: $35,000
Project Summary Fossil corals contain a rich archive of past climate variability for tropical oceans which can extend the limited instrumental data and increase our understanding of climate sensitivity. El Niño variations in the Pacific have farreaching impacts on Australian climate, and this project will reconstruct variations in the past in order to better forecast climate sensitivity in the future. It focuses on Christmas Island which is the optimal site to capture El Niño variability at several different time scales, and will lead to a better understanding of atmospheric and oceanic factors that have caused climate variability.

ECOLOGY AND EVOLUTION

CI's: Prof A Cooper; Prof TF Flannery
Using ancient DNA to investigate the environmental impacts of climate change and humans through time
The University of Adelaide
2006: $160,000; 2007: $155,000; 2008: $155,000
Project Summary This project will provide important information about how climate change and human impact have effected our environment over the past 50,000 years, removing many of the large mammals and altering the landscape. It is critical that the background to our current environment is properly understood if we are to predict the effects of ongoing changes such as global warming. The research will concentrate on the effects of climate change on large mammals in North and South America, New Zealand, Australia and Africa over this time period, and will examine the additional impact of humans in each location.

GEOCHEMISTRY

CI's: Prof Dr R Grun; Prof MJ Spriggs; Dr IS Williams
Microanalysis of human fossils: new insights into age, diet and migration
The Australian National University
2006: $105,000; 2007: $90,000; 2008: $90,000
Project Summary Human occupation of Australia and the Pacific dates back tens of thousands of years. New microanalytical techniques now make it possible to learn about the life histories of these ancient peoples: their diet, migration paths and the climate in which they lived. This project will benefit the Indigenous populations and researchers of neighbouring countries through collaboration and increased knowledge of their ancestors, thus enhancing Australia's links and status as a good neighbour in the region. This falls squarely into the Research Priority 'Safeguarding Australia Understanding our Region and the World'. In the future, our analytical approach will give important insights into the complex and rich archaeological heritage of Australia.

CI's: Prof RG Roberts; Prof Dr R Grun; Dr Z Jacobs; Dr GA Duller
Out of Africa and into Australia: robust chronologies for turning points in modern human evolution and dispersal
University of Wollongong
2006: $86,000; 2007: $30,000; 2008: $60,000; 2009: $70,000; 2010: $70,000
Project Summary This project will yield important new data on the timing of major turning points in human evolution and the human colonisation of Australia. This will improve our knowledge of Aboriginal cultural heritage and provide a longterm perspective on human/environment interactions to help forecast future impacts of human disruption of the Australian ecosystem (Environmentally Sustainable Australia NRP). Modern dating techniques underpin many archaeological and environmental projects, so the advances made in this study will benefit researchers worldwide, increase capacity for commercial services, and enhance Australia's international standing in geochronology. We will also generate highquality research students and new collaborative initiatives.

GEOLOGY

CI's: Prof GC Nanson; A/Prof BG Jones
Palaeoclimatic and environmental significance of major Late Quaternary drainage contributions and disruptions in the Lake Eyre basin.
University of Wollongong
2006: $110,000; 2007: $80,000; 2008: $80,000
Project Summary This study will advance our knowledge of the most remarkable floods ever known to have occurred in Australia. They were associated with a vast aquatic ecosystem in what today is the barren northern end of the Flinders Ranges, a region of desert dunes and salt lakes. Remarkably, such wet conditions appear to have coincided with episodes of megafaunal extinction and with the human occupation of Australia. The results will provide valuable information with which to better understand the the main global drivers of episodes of profound wetness and dryness in Australian climate.

CI's: Dr JD Woodhead; Prof PW Williams; Dr F McDermott
Of caves, bones, and climate change: new insights from old speleothems
The University of Melbourne
2006: $80,000; 2007: $80,000; 2008: $80,000
Project Summary Australia has an enviable reputation as a leading innovator in geochronological studies and this research will reinforce that standing. The outcomes will have an immediate and significant impact on studies of global climate change, and provide new insights into the evolution of Australia's unique fossil mammal fauna. In these ways, and as described in more detail elsewhere in the application, this project addresses directly our current national research priorities 'responding to climate change and variability' and 'the sustainable use of Australia's biodiversity'.

QEII: Dr SW Wroe
Australia's mammalian carnivore diversity in space and time
The University of New South Wales
2006: $200,000; 2007: $150,000; 2008: $150,000; 2009:$125,000; 2010: $125,000
Project Summary To more effectively address the current extinction crisis we need to understand past diversity. This research program will comprehensively investigate the diversity of mammalian carnivores on three continents over geological time. Results will provide insight into whether the evolution of Australia's mammal carnivores differs fundamentally from those of other continents, as has often been suggested but not quantitatively demonstrated. Studies focused in the present are important, but often miss critical factors that can only be clarified through analyses with deep time perspectives. The findings will translate into an improved understanding of what makes Australia unique and better informed decisions regarding wildlife management.

Linkage Grants

ECOLOGY AND EVOLUTION

CI's: Dr PA Gell; A/Prof DM McKirdy; Dr J Tibby
Retrospective ecological character assessment for a review of Ramsar status of The Coorong, SA.
The University of Adelaide
2006: $100,000; 2007: $49,220
Partner Organisation(s)
Department of Water, Land and Biodiversity; Conservation (DWLBC) I & B Division Upper South East Program; Department for Environment and Heritage SE Region
Project Summary Integrated analyses of the chemical and biological remains contained in the sediments of the Coorong will provide for a reconstruction of ecological change and variability over the last several thousand years. Detailed analyses of the recent sediments will measure how the condition of the Coorong has departed from this natural background and so provide an audit of human impact on the last wetland in the Murray darling Basin. This evidence will directly inform the determination of the ecological character of this Ramsar listed, national ecological asset and steer its management for a sustainable future.

CI's: Dr J Tibby; Dr PA Gell; Mr PJ Leahy
New approaches for protecting stream health in temperate Australia: Devising nutrient and salinity guidelines using diatoms
The University of Adelaide
2006: $24,650; 2007: $24,650; 2008: $24,650
Partner Organisation(s)
Environment Protection Authority (South Australia)
Environment Protection Authority (Victoria)
Project Summary Salinity and nutrient enrichment are the most significant forms of water quality degradation in Australian lowland rivers. This project will identify the biological effect of the water quality pollution and develop new methods for its assessment. Most importantly, through the identification of water quality "thresholds" which result in reduced biodiversity, better guidelines for maintaining stream health will be developed.

Linkage Infrastructure Grants

SOIL AND WATER SCIENCES

CI's: Dr RN Drysdale; Dr ID Goodwin; Dr SW Franks; Dr JD Woodhead; Dr J Zhao
A highthroughput stable isotope ratio mass spectrometer for water resource management and climate change studies
The University of Newcastle
2006: $100,000
Partner Organisations
The University of Newcastle; The University of Melbourne; The University of Queensland
Project Summary Cave speleothems are highly sensitive to climate and are widely used to investigate past climate variability. Many researchers in Australia are now employing speleothems to find out more about the longterm behaviour of the Australian climate system, especially regarding ENSO. However, progress is inhibited by a lack of appropriate instrumentation capable of meeting the unique demands of speleothem research. Our new mass spectrometer will provide precise, rapid and lowcost isotope analyses of speleothem samples, and in doing so generate exciting and important palaeoclimate data, particularly in the area of preinstrumental rainfall histories.

GENETICS

CI's: Prof A Cooper; A/Prof MP Schwarz; Prof SC Donnellan
Expansion and enhancement of the South Australian Regional Facility for Molecular Ecology and Evolution and the Australian Centre Ancient DNA
The University of Adelaide
2006: $115,000
Partner Organisations
The University of Adelaide; The Flinders University of South Australia; South Australian Museum
Project Summary Provision of dedicated instruments for contemporary and ancient/fragmentary DNA analyses will provide numerous opportunities for innovative research solutions in basic biology, archaeological, agricultural, biomedical, forensic and environmental sciences. No similar combination of facilities currently exists in the Australian region severely curtailing and jeopardising the quality of current and proposed research programs. The facilities will underlie innovative approaches to research in National Research Priorities 1 and 4 An Environmentally Sustainable Australia and Safeguarding Australia.

QUATERNARY NEWS

From Fawn Ginn, University of Manitoba

At the 2003 International Paleolimnology Symposium, held in Finland, there was widespread support for the development of an international society or association of paleolimnologists. This effort was led by Rick Battarbee, and a small ad hoc committee was struck at the Finland meeting to explore further the formation of a paleolimnology association.

The first draft of a Constitution and Mission statement has been posted on the IPA web page at *www.umanitoba.ca/geoscience/paleolim/ipa.html* Anyone interested or working in paleolimnology is invited to comment on this preliminary draft and make suggestions relative to the Association.

It is anticipated that the constitution and Association will be formalized at the next International Paleolimnology Symposium, to be held June, 2006, in Duluth, Minnesota.

The OZ INTIMATE website is now up and running at *www.uow.edu.au/science/eesc/research/oz_intimate/index.html*

The Australian Quaternary Top 10

Paul Hesse

Lists of the 'best ever' this or that are an evil we've learned to live with in the fields of sport, music, movies and even art. At best you learn about some real classics you didn't know about, at worst you get to argue with the list-maker (perhaps only in your head) about their inexplicable exclusion of your own favourites and the equally inexplicable inclusion of complete dross that surely no-one with any taste or intellect could consider worthy.

With the eyes of the Quaternary world to turn on Australia in 2007 for the INQUA Congress, what would be the papers you'd recommend to a foreign delegate to bring them up to speed (or set them straight) on the Australian Quaternary? That idle question prompted me to ask AQUAlist members for their suggestions of the 'classic' papers on Quaternary Science in Australia. I received a good number of responses that revealed the breadth of the field and its history as well as a range of interpretations of what it means to be 'classic' (this included a couple of 2005 papers).

I did find that a lot of my favourites were widely popular and also that some weren't. I also discovered a few new papers to read (and appreciate). I have decided to put down a list of sorts based on both the responses I received and a heavy bias of my own. I have resorted to the hated citation databases (ISI Web of Science) to get some feel for how influential these papers are, but this was a small component in the decision-making process. In sorting through these papers I found that I did learn a lot about the history of Quaternary science in Australia. Some of the major developments in our field inevitably occurred outside Australia and are not reflected here. Others, such as radiocarbon dating, may have been developed and applied first outside Australia but their effect here was profound. Other developments have shaped our discipline's and, I like to think, Australian society's view of our environment and could only have occurred here. Nevertheless, some of the classics need updating because of advances in dating, proxy data or interpretation, and the list could not be contained to just 10 papers.

Thanks to all those who contributed nominations and feedback (but who should not be held responsible for the list or the comments made): Peter Kershaw, Fawn Ginn, Mike Barbetti, Martin Williams, Tim Barrows, Simon Clarke, Gresley Wakelin-King, Stuart Pearson, Peter McIntosh, Pandora Hope, Maria Cotter, Jon Nott, Bob Haworth, Geoff Humphreys, Leanne Armand, and Kathryn Taffs.

Pre-radiocarbon

1. Schumm, 1968
***Geol Soc Am Prof Paper* 598**
150 CITATIONS

This could be said to be really a geomorphology paper rather than a Quaternary paper, but it was widely influential (inside and outside Australia) and fed into an ongoing debate over the palaeohydrological history of the Murray-Murrumbidgee Riverine Plain. Schumm's paper gave the long-lasting story of fluvial response to late Quaternary climate change in more detail than the original work of Butler (1950, *Aust J Ag Res* 1: 231). The debate over the hydrological and climatic interpretation of the palaeochannels was already ignited at the time of Schumm's contribution and remained alight for some time afterwards. Butler's experience of the palaeochannels of the Riverine Plain fed his K-cycle model (Butler, 1959. *CSIRO Soil Pubn.* 14) which was very influential through the 1960s and 1970s linking climate, deposition/erosion and soil formation, but has now waned in popularity, partly because of a more sophisticated understanding of landscape response to climate change and a real chronology to work with. The first introduction of numerical dating into the debate over the palaeochannels was Jim Bowler's 1967 paper (*J Geol Soc Aust* 14: 287) on the Goulburn River palaeochannels which gave one of the very first chronologies of events through the LGM in Australia, back to 30 000 radio-carbon years. The (so far) final word on both the chronology and geomorphic interpretation of the Murrumbidgee palaeochannels studied by Schumm rests with Page et al. (1996, *J Quat. Sci.* 11: 311), who broke the radiocarbon barrier with the application of luminescence dating, extending the record back to over 100,000 years.

2. Butler, 1956
***Aust J Sci 18:* 145**
70 CITATIONS

This little paper has had a lasting impact in both Quaternary science and soil science although I will readily concede that my personal bias is showing here. I, personally, always prefer the companion paper by Butler and Hutton (1956, *Aust J Agr. Res* 7: 536), with half the citations, because it actually has data! Together these papers put a name to widespread 'desert loess' in Australia: parna. Give me a couple of drinks and I'll tell you why I don't like that name, but at the time the concept of 'hot loess' was both new and controversial (although dust

additions to soils in Australia had been talked about at least as early as 1937 by Leeper, *Proc Roy Soc Vic* 49:77-134) and there were good reasons for avoiding the term loess (which have since vanished). No chronology was provided in these papers or forthcoming in subsequent work. When Thiede (1979, *Geology* 7: 259) provided a continuous record of dust in marine sediments linked to the marine oxygen isotope chronology, it was the first time a chronology had been given to what had widely been seen as a proxy of aridity in Australia. McTainsh's 1989 paper (*QSR* 8: 235) provided a good summary of the state of knowledge up until that point, drawing geomorphic, meteorological and sedimentological studies together. I will be immodest and mention my own little paper on dust in Tasman Sea sediments which provides a more reliable chronology and longer coverage than earlier work (Hesse 1994, *QSR* 13: 257).

3. **Galloway, 1965**
***J Geology* 73:603**
82 CITATIONS

Tim Barrows provided a strong endorsement of this highly regarded paper which "…finally dispelled the myth that 'glacials' were 'pluvial'; rather dramatic drops in temperature greatly reduced evaporation at the same time precipitation was also greatly reduced. This set the stage for much of the later Australian Quaternary hydrological work, and his climate estimates are still pretty much spot on. All without dating!" In fact, the impact of this paper extends into many fields: glacial geology, palaeohydrology and palaeoecology. Significant papers which built our knowledge of glacial events are those of Colhoun (1985, *Quat Res.* 24:39) and Colhoun and Fitzsimons (1990, *QSR* 9: 199) in Tasmania and Barrows *et al.* (2001, *Quat Res.* 55:179) with what I think is the first published 'cosmo' chronology of Australian glaciation from Kosciuszko. Cosmogenic radionuclide exposure dating has brought forth a new wave of results and ideas which is continuing now.

The radiocarbon revolution

4. **Bowler et al., 1970**
***World Archaeol* 2:39**
67 CITATIONS

Mungo has become one of the 'classic' sites in the Australian Quaternary, but it has also generated an enormous literature and it is quite difficult to pick a single paper which captures the breadth of the archaeological and geomorphic detail. This paper, however, is the original and contained the '40,000 year' figure for human occupation of Australia which, I think, has become one of the most powerful political ideas in Australia in the time since (even though we still can't agree on the age). Other papers (Bowler *et al.*, 1972. *Nature* 240:48; Bowler, 1998. *Archaeol. Oceania* 33:120; Bowler *et al.*, 2003. *Nature* 421:837) refined and updated the dating and the findings but the most widely cited paper that came out of Mungo may be Bowler's (1973, *Earth Sci. Rev.* 9: 315; 78 citations) synthesis of clay dune (lunette) formation.

5. **Bowler and Hamada, 1971**
***Nature* 232:330**
47 CITATIONS

Lake Keilambete may be the first lake core in Australia with a published radiocarbon chronology (someone will tell me if I'm wrong) going through the LGM and remains an important palaeohydrological record. Its place as a classic is warranted because it was the first of a wave of papers published in the early 70s which used radio-carbon chronologies and continuous sediment records and gave us the framework for late Quaternary climate and environmental change that still survives. Dodson's Keilambete Holocene pollen record is more widely cited (1974, *Aust J Bot* 22:709; 65 citations) and was an early dated pollen record, beating Lake Leake by a year (Dodson, 1975. *Aust J Bot* 23: 815–31).

6. **Kershaw, 1974**
***Nature* 251:222**
48 CITATIONS

Lynch's Crater remains one of the 'classic' sites in the Australian Quaternary. This was the first of several papers which gradually increased the length of the pollen record and improved the age model (Kershaw, 1978. *Nature* 272:159; Kershaw, 1986. *Nature* 322:47; Kershaw, 1994. *Palaeo*^{3} 109: 399) but even in this first paper we had the earliest published dated Pleistocene pollen record from Australia – one that graphically showed both the history of the rainforest and the indication of human burning beginning at 40 ka. Remarkably both the date and interpretation seem to have stood the test of time, even if human occupation of Australia itself is now known to have occurred earlier.

Going Global

7. **Chappell, 1974**
***Geol Soc Am Bull* 85:553**
289 CITATIONS

The enduring impact of this paper is probably due both to the global interest in sea-level and the degree of detail of dating, environmental interpretation and geology included in the first complete paper on the Huon Peninsula sea-level record. The shorter paper published in the same year (Chappell, 1974. *Nature* 252: 199) garnered only 38 citations. This can be a new justification for 'choosing' to have none of your papers in *Nature*. Numerous papers followed, both refining the Huon story and also extending

the scope (Chappell and Veeh, 1978. *Geol Soc Am Bull* 89:356; Chappell, 1983. *Search* 14:99) leading to the most highly cited paper I encountered in this exercise (Chappell and Shackleton 1986. *Nature* 324:137; 707 citations), which compared the Huon sea-level curve to the global oxygen isotope curve to derive deep-water temperature history. A later round of dating culminated (?) in a revised chronology with greater precision and detail (Chappell *et al*. 1996. *Earth Planet Sci Lett* 141: 227). A much earlier paper on global sea levels included some of the first references to Australian sites (Fairbridge, 1961. *Phys Chem Earth*) but is now superseded. There have been several notable papers developing Australian sea-level records (Thom and Chappell, 1975. *Search* 6:90; Stirling *et al*., 1995. *EPSL* 135: 115; Yokoyama *et al*., 2000. *Nature* 406: 713) and a recent synthesis (Lambeck and Chappell, 2001. *Science* 292: 679) with improved detail in the last inter-glacial and glacial maximum extremes.

8. Hope, 1976
***J Ecol* 64: 627**
75 CITATIONS

Although this paper appeared earlier, another paper (Walker and Flenley, 1979. *Phil Trans Roy Soc Lon B* 286: 265–344; 89 citations) was in preparation at the same time. Data from both appeared in the 1976 synthesis paper (see number 9). Both papers deal with palaeoecology in the New Guinean highlands: Hope with Mt Wilhelm and Walker and Flenley with Enga Province. Both studies traced movement of the tropical tree-line through dated records extending to the late Pleistocene. The substantial depression of temperatures inferred (eight degrees or so) has remained as inspiration and frustration to palaeoclimatologists' attempts to understand climate change in the tropics ever since. The other widely quoted figure for LGM temperature in the region came from Galloway's 1965 estimate for Kosciuszko and both came under scrutiny after the CLIMAP reconstruction showed comparatively little change in SST around Australia and especially in the tropics. Miller *et al*. (1997, *Nature* 385: 241) again found evidence of a large temperature drop, in inland Australia, and the pendulum began to swing back again (Barrows *et al*., 2000. *Palaeoceanography* 15: 95; |Barrows and Juggins, 2005. *QSR* 24: 1017).

Pause for breath

9. Bowler et al., 1976
***Quat Res 6*: 359-394.**
211 CITATIONS

After the rapid appearance of new studies from all over Australia and New Guinea in the late 1960s and early 1970s a review of the complete picture was timely. 'Late Quaternary Climates of Australia and New Guinea' brought together the stories from the Western Plains, Tasmania, Mungo, Lynch's Crater and the still unpublished Lake George record to make a coherent picture of the Late Quaternary climate picture of the continent. In particular, the paper made a compelling case for LGM aridity and the timing of the LGM in Australia.

10. Bowler, 1976
***Earth Sci Rev*, 12:279**
190 CITATIONS

'Aridity in Australia' was the seminal review of the evidence of Quaternary climates and landscapes of the Australian arid zone. Although overwhelmingly dominated by the Lake Mungo story, the paper brought together the scant evidence available from Lake Eyre and Lake Frome, the Southwest and other sites. The prediction of the southeast and northwest dust transport paths remains, for me, a major achievement of this paper. Later papers (e.g. Bowler and Wasson 1984. *SASQUA International Symposium*. Editor J.C. Vogel *et al*. Rotterdam. Balkema.) added further data but Nanson *et al*. (1992, ('wetting and drying') *Geology* 20:791) contributed a major advance with substantial TL dated dune and fluvial sequences. A major parallel contribution was the documenting of archaeological evidence of human occupation of the arid zone through the LGM (Smith, 1989. *Archaeol. Oceania* 24: 93). An important recent addition to arid Australian Quaternary records is the 150,000 year Lake Eyre record (Magee *et al*., 2004. *Geology* 32:885).

11. Webster and Streten, 1978
***Quat Res 10*: 279–308**
130 CITATIONS

This paper represents something which has all too rarely been attempted in Australian Quaternary Science: atmospheric scientists coming to grips with the proxy palaeoclimate record and suggesting mechanisms for the changes, in this case with a conceptual climate model. Wyrwoll *et al*. (2000, *QSR* 19, 881-893) is also notable as one of the few papers describing General Circulation Model results over the region to test hypotheses drawn from the proxy evidence. Miller *et al* (2005, *Geology* 33: 65) have also addressed specific questions generated from proxy studies with GCM simulations.

12. Singh et al, 1981
in *Fire and the Australian Biota*,
Aust Acad Sci.
96 CITATIONS

While fire had previously been regarded as important in the Australian environment (e.g. Jones, 1969. Firestick farming. *Aust. Nat. Hist*. 16:224) this paper is significant in being one of the first systematic charcoal papers and pointing conclusively to the role of fire here. Combining

data from Lynch's Crater, Lake George and Kangaroo Island, the paper both laid out a hypothesis and stimulated continuing controversies. There has been a large and divided literature (e.g. Bowman, 1998. *New Phytol.* 140:385) on the role of fire, and charcoal, ever since (see 14). Nevertheless, this issue has reached far into everyday land management in Australia where historical justifications for burning, or not burning, are regularly made.

Beyond radiocarbon

13. Roberts et al., 1990
***Nature 345*: 153**
147 CITATIONS

While the first applications of thermoluminescence dating in Australia go back to the mid 1980s, with Gardner *et al*'s (1987, *Aust J Earth Sci* 34: 343-357) and Readhead's (1988, *QSR* 7: 257-264) dating of sand dunes, the first application which really turned heads was this paper dating early human occupation at Malakananja II and Malangangerr to 50,000 years, breaking the radiocarbon barrier. Later studies have increased the number of dated old sites, both with TL (Roberts *et al.* 1994. *QSR* 13:575) and AMS ^{14}C (Turney *et al.* 2001. *QSR* 55:3) making 50,000 'the new 40,000'. New discoveries on human dispersal and evolution in the region keep coming, with the recent dramatic revelations of late Pleistocene dwarfed *H. erectus* in Flores (Morwood *et al.* 2004. *Nature* 431 1087-1091) adding fuel to the now decades-old debate on 'regional continuity' (Thorne, 1981. *Am J Phys Anthropol*) versus 'out-of-Africa'.

14. Roberts et al., 2001
***Science 292*: 1888–1892**
66 citations

The debate over the megafaunal extinctions in Australia is easily the most acrimonious and divisive in Australian Quaternary science today. Nothing I can say will sort through the various positions and claims but this paper has really set the level for the evidence required to begin to test the various hypotheses. I toyed with nominating Flannery's Pleistocene 'blitzkreig' paper (1990, *Archaeol. Oceania* 25: 45–67) because it was so incendiary, but the Roberts *et al.* OSL dating of the best sites to give an age of 46,000 years for the most recent extinctions cuts through earlier speculations. The nature of the argument means that other sites may yet be found with sufficiently high quality evidence to cause dramatic revision of that date, but the first test of it, the demise of *Genyornis* (Miller *et al.* 1999. *Science* 283: 205), yielded the same age. Debate still rages on the cause, as well as the timing, of the extinctions including valuable studies of coincident environmental change (Johnson *et al.* 1999. *Science* 284: 1150; Miller *et al.* 2005. *Science* 309: 287) that may or may not be related to human activities such as burning.

Down-scaling

15. Gagan et al., 1998
***Science 279*: 1014**
100 CITATIONS

This paper built on earlier work (Gagan *et al.* 1994 *EPSL* 121: 549; McCulloch *et al.* 1994. *Geochim et Cosmochim* 58: 2747; Alibert and McCulloch, 1997. *Paleoceanography* 12: 345) to establish a new methodology for examination of extremely high resolution records from the past. The monthly, or better, resolution of coral cores from the Great Barrier Reef allowed seasonal temperature estimates (separating temperature and salinity effects) to be made, in this case for the mid-Holocene. In some ways the results brought us back around to the tropical temperature paradox noted above (number 8) but also pointed to long histories resolving ENSO around tropical Australia. The trend since has been toward very high resolution records (e.g. the Tasmanian Huon pine record first published in Cook *et al.*, *Science* 253: 1266) capable of accurate resolution of extreme events, as well as mean states. Another approach was the dating of cyclone-generated beach ridges (Nott and Hayne, 2001. *Nature* 413: 508), part of the emerging field of 'palaeotempestology'.

Well, there it is. Like most of these things, the inclusions probably won't raise many eyebrows, but the exclusions may. On reflection, I think there are opportunities for others to compose different lists (OK, maybe forget the list idea) with different biases. For example, it seems to me that there are generations of pre-1960s scientists whose work I have largely ignored. I suppose my defense is that in most cases the work is now often compromised by the new chronologies, by new paradigms (such as plate tectonics) or simply by new data. Nevertheless, there is much early work which is still valid and genuinely fascinating because of the conditions under which the information was won. Likewise, there is a whole technical literature, to do with dating or other analytical methods, in which Australian scientists have played an important part. I resisted going down this path because it really is a much more international effort, but there is much of historical interest here. I'm sure others will find other aspects to muse on. I encourage you to act constructively (more contributions to *QA* encouraged!) and not abuse the list-maker.

Yukon Ho:

International Field Conference and Workshop on Tephrochronology and Volcanism

Dawson City, Yukon Territory, Canada
31 July – 8 August 2005

Siwan Davies SCOTAV Vice-President,
Department of Geography, University of Wales,
Swansea, United Kingdom

Brent Alloway SCOTAV Secretary,
GNS Science, Gracefield Research Centre,
PO Box 303–68, Lower Hutt, New Zealand

The fourth inter-congress meeting of the INQUA Sub-Commission on Tephrochronology and Volcanism (SCOTAV), convened by **Duane Froese** (University of Alberta) and **John Westgate** (University of Toronto), was recently held in Dawson City within the beautiful Canadian Yukon Territory. This international field conference and workshop maintains the long tradition of very successful inter-INQUA meetings held previously by SCOTAV (including the USA, New Zealand and France) over the past 15 years. Not only do these meetings facilitate an opportunity for the presentation and discussion of latest advances in tephra studies, but they also provide an exceptional insight into the palaeoenvironmental history of a specific region, in this case, the Yukon Territory.

The unglaciated region of Yukon and Alaska (collectively known as eastern Beringia) is scientifically unique. The lack of glaciation has resulted in the preservation of Cenozoic paleoenvironmental archives that are seldom recorded elsewhere in North America. Many of these archives are uniquely preserved in areas of relict permafrost, and unlike permafrost areas of eastern Eurasia, the occurrence of numerous distal tephra beds originating from the Aleutian arc-Alaska Peninsula and Wrangell volcanic field makes the correlation and dating of many of these archives accessible by a variety of methods. The Yukon also has an interesting mining history commencing with the Klondike Gold Rush of 1898. Since that time over 16 million crude ounces of placer gold have been mined from Yukon Territory, 85% of which is derived from unglaciated areas where gold-bearing gravels are often buried by thick sequences of frozen organic-rich silt (locally referred to as 'muck') that preserve tephra and fossils (bones and soft tissue remains) (Fig.2). In many cases, the identification of key stratigraphic sequences in eastern Beringia can be directly attributed to gold-mining

Figure 1: View of Dawson City and Yukon River from Midnight Dome.

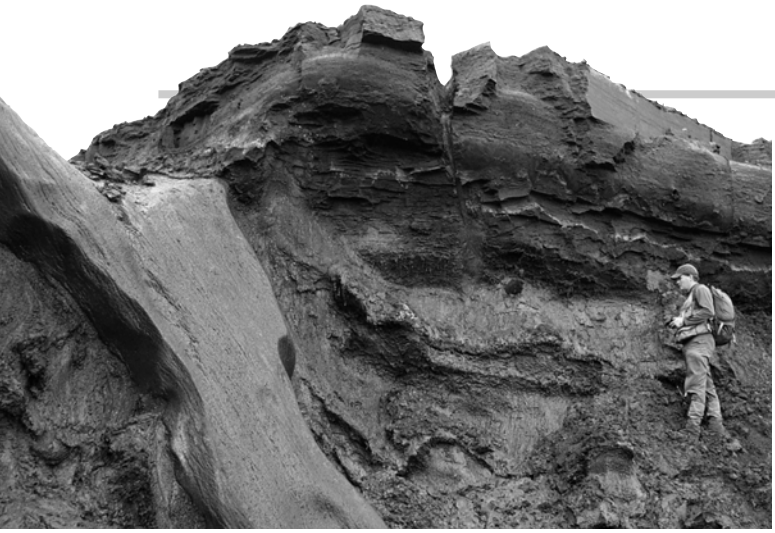


Figure 2: Tephra overlying a prominent paleosol in 'muck' sequence at Christies Claim, Dominion Creek, Klondike Goldfields. Note the prominent ice-wedge to the left. Duane Froese for scale.

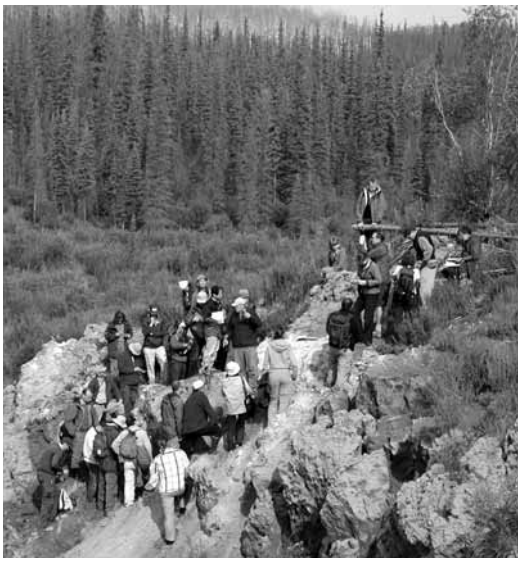
operations that strip away this overburden material to expose the underlying gold-bearing gravels.

Thirty four participants from fifteen countries attended the meeting that officially opened with an ice-breaker reception amongst stuffed woolly mammoths, ground sloths and scimitar cats at the Yukon Beringia Interpretative Centre in Whitehorse. In association with the Yukon Science Institute, two public talks, given by **Grant Heiken** (Los Alamos, New Mexico), were arranged as part of the conference – the first of which took place at the ice-breaker reception and the second at Dawson City. With over 40 years experience in the field of volcanology and tephra studies, Grant Heiken explored the different human perceptions of volcanoes and the risks of living in the shadow of a volcano.

On the following morning the participants headed north to Dawson City, the heart of the Klondike Gold Rush at the end of the 19th century, and for us the centre of the 'Tephra Rush' conference activities. The long trip north was interspersed with a number of field stops that marked a journey back in time, from the Five Finger Rapids along the Yukon River that lies in close proximity to the limits of the last glaciation (McConnell), to the early Pleistocene Wounded Moose palaeosol. Local culinary delights were also sampled along the way with a very memorable stop at a roadside café serving the largest cinnamon buns in the world – breakfast for many participants for the next four days!

This first day also gave us our first glimpse of the tephrostratigraphy of this region as the White River Ash flanked parts of the road north (Fig.3). The White River tephra forms two distinct lobes spreading east and north from an assumed common source, the late Holocene eruption of Mount Churchill in southeastern Alaska. The northern lobe is the older (1887 14C BP), less extensive of the two lobes and extends north from the source area straddling the Alaska-Yukon border. The younger eastern lobe (1147 14C BP), is more widespread extending over much of southern Yukon and extending into the Mackenzie Valley of the adjacent Northwest Territories. The White River tephra is central to the leading hypothesis explaining a migration of northern Athapaskans from southern Yukon and Alaska about a thousand years ago. The hypothesis is based primarily on linguistic evidence which indicates that southerly populations of Athapaskan speakers, including the Navajo and Apache, were derived from a northern proto-Athapaskan population. Recent genetic evidence is consistent with the hypothesis, but archaeological evidence both within the source area and along presumed migration paths is scarce. **Greg Hare** (Yukon Department of Tourism and Culture) and **Duane Froese** reported, in a paper presented at the conference, the recovery of organic artifacts from perennial snow patches in southern Yukon which allows precise ages to be directly determined on cultural materials immediately prior to and following the eruption of Mount Churchill. A recent wiggle-match radiocarbon age indicates that the White River eruption occurred about 800 AD, and was coincident with the transition in southern Yukon from atlatl and throwing dart technology to the adoption of the bow and arrow, which were likely present a few hundred years earlier in southern Alaska. The results suggest that a proto-Athapaskan population inhabiting the region was strongly affected by the ecological impacts of the volcanic eruption and migrated, at least temporarily, out of the thick tephra-fall region to encounter this technology. This migration may have either displaced surrounding peoples as a ripple effect of the catastrophe, or pushed a small founding population of Athapaskan speakers to the south. While the dynamics of the technological transition are still unclear, the impact

Figure 3: White River tephra (c. 800 AD) exposed near the present-day ground surface, Whitehorse-Dawson City Highway. The White River tephra is the leading hypothesis to explain a migration of northern Athapaskans from southern Yukon and Alaska about a thousand years ago. John Westgate on microphone.



Figures 4 and 5: John Westgate (centre) explaining to the group the stratigraphy associated with Dawson Tephra (c. 24 ^{14}C ka BP) at Quartz Creek. The Dawson Tephra overlying a prominent ice-wedge. The Dawson tephra is the most prominent tephra (typically 15–30 cm thick) in the Pleistocene deposits of the Klondike area and has been so far identified at twenty sites in western Yukon.

of the White River eruption and its synchroneity with technological change is consistent with eruption-diaspora hypothesis.

The talks and poster sessions were spread over three days with 44 presentations given in eight themed technical sessions. Both oral and posters presentations demonstrated the enormous diversity of tephra studies conducted by the participants with session themes ranging from regional tephra studies (Beringia, New Zealand, Japan, Indonesia, Ethiopia and Argentina), advances in geochemical characterisation techniques, the application of cryptotephra investigations for correlating terrestrial, marine and ice-core records, the dating techniques available for tephrochronology studies and the environmental impacts of volcanic eruptions. Some noticeable highlights included a presentation by **Nick Pearce** (University of Wales, Aberystwyth) on the latest advances and future potential of employing Laser Ablation ICP-MS techniques for single-shard analyses, and the strides made by **Gustavo Villarosa** (Universidad Nacional del Comahue) and **Kaori Aoki** (Geological Survey of Japan) in developing a tephrochronology framework for NW Patagonia and the NW Pacific Ocean, respectively. The posters presented also emphasised the diverse nature of the tephra work currently ongoing amongst SCOTAV members – ranging from the impact of volcanism on early Maori society in New Zealand (**David Lowe**; University of Waikato) and 10th century central Javanese society (**Supriyati Andreastuti**; Directorate of Volcanology and Geological Hazard Mitigation, Indonesia) to the characterisation of Pliocene – Early Pleistocene marker tephras in central Japan (**Itoko Tamura**; Tokyo Metropolitan University). A magnificent conference banquet of local delicacies prepared by members of the local Han First Nations, and an entertaining and enlightening after-dinner presentation by **Paul Matheus** (Yukon Department of Tourism and Culture) on the Beringian mammals brought the technical days to a close.

The last 2 days of the meeting were dedicated to a field excursion in the Klondike Goldfields led by **Duane Froese** and **John Westgate**. A fascinating tour of Plio-Pleistocene gravels, loess deposits and excellent examples of ice-wedge casts highlighted the central role of tephra horizons in providing age control and precise tie-points between sequences in this region – work that has been predominantly led by **John Westgate** over the last 20 years (Fig.4). Indeed, a number of different tephra horizons were observed from the reworked pods of the Midnight Dome tephra (c. 1.09 Ma), thin discontinuous layers of the Quartz Creek tephra (c. 2.97 Ma) and the thick deposits of the Dawson Tephra (24 ^{14}C ka BP) (Fig.5). The varied degrees of preservation emphasised the complex nature of undertaking tephra studies in this region. In addition to the well-known tephra horizons of this region, some 'new' undiscovered tephra horizons were also identified during this excursion – maybe hereafter named the SCOTAV tephras? By far, the highlight of the excursion was the visit to the 'muck' exposures, the fine-grained ice-rich deposits of late Pleistocene age that overlie gold-bearing gravels, and contain well-preserved megafaunal remains. Gumboots essential! It is probably one of the few areas of the world in which you can really experience the putrid smell of the Plio-Pleistocene!

Anyone interested in any aspect of tephrochronology and/or volcanism can visit our website: ***http://www.gns.cri.nz/inquatephra/*** or contact SCOTAV secretary Brent Alloway: ***b.alloway@gns.cri.nz*** to find out more about SCOTAV membership, activities and upcoming events. The Proceedings of the recent meeting held in the Yukon can be freely downloaded from the SCOTAV website.

Southern Deserts II:

2nd Southern Deserts Conference: Human — Environment Interactions in Southern Hemisphere Deserts: Past, Present and Future

Arica, Chile, 7–17 October 2005

Pauline English
CSIRO, Australian National University

with contributions from:
Matt Cupper, University of Melbourne;
Paul Hesse, Macquarie University
Steve Webb, Bond University
John Magee, Australian National University

This conference was the second of a series of three conferences aimed towards a comparative southern hemisphere view of how humans interacted with and responded to the evolution of arid environments from pre-historic to modern times. The first Southern Deserts conference was held in Canberra in January 2003 under the auspices of Mike Smith, Research Director of the National Museum of Australia. The focus of the conferences is the environmental and cultural heritage of the 'Tropic of Capricorn' deserts: the Namib and Kalahari in Southern Africa, the Red Centre in Australia, and the Atacama in South America. Many of us remember that first conference vividly as it coincided with the week of horrific bushfires that lapped Canberra, when we witnessed black skies and burning cinder falling in Lake Burley Griffin whilst taking coffee breaks on the Museum jetty. It was just before announcements on the Museum intercom for residents of the ignited western suburbs of Canberra to go home that Calogero Santoro of the Universidad de Tarapacá, Arica, and Claudio Latorre of the Universidad Católica de Chile, Santiago, invited us all to a 2nd Southern Deserts Conference to be held in the Atacama Desert in Chile in 2005.

Stone-terraced slopes at Putre village, 3500 m asl in the pre-Cordillera, inhabited by indigenous Aymara people. Snow-clad Cerro Larancagua, 5400 m, at the head of the valley.

The objective of this conference has been to further enhance networks of interdisciplinary scientific cooperation to bring together a broad range of specialists from environmental and social sciences. The momentum has been maintained to a large extent during the intervening period by Mike Smith with the wonderful *Extremes: Survival in the Great Deserts of the Southern Hemisphere* exhibition at the National Museum and publication of: *Desert Peoples: Archaeological Perspectives* (Veth, P, Smith, M and Hiscock, P, eds., 2004, Blackwell Publishing) and *23°S: Archaeology and Environmental History of the Southern Deserts* (Smith, M and Hesse, P., eds., 2005, National Museum of Australia Press).

There were no bushfires to greet us in Arica. In fact, there is no bush at all, not even a blade of grass. The remote city is surrounded by completely barren hills that are composed of uplifted Jurassic marine sediments. The Chilean conference was vivid for very different reasons: the sheer sense of geography of the place; desert lands utterly bereft of vegetation abutting snow-capped volcanoes; tiny adobe villages set amidst ancient Inca-built terrace fields clinging to steep rocky mountainsides; colourfully-clad Aymara, Quechua and Atacaman shepherds herding flocks of llama and alpaca; gigantic geoglyphs embroidered onto barren hillslopes

Río Lluta valley, close to the Peruvian border, in which streamflow is derived from distant snow-clad Andean volcanoes, watering alfalfa fields to feed llama and alpaca.

a thousand years ago by Inca traders – representing some of the largest archaeological relics in the world; herds of wild vicuña grazing altiplano wetlands; pink flamingos foraging in brine pools of salt lakes amidst snowy mountains; ghost towns set on Tertiary lakebeds that have been plundered of nitrate deposits; rickety cities perched on the edge of the Pacific, full of ornate Spanish colonial architecture and cobble-stoned lanes; ignimbritic canyons dotted with giant pencil cacti; the sound of pan flutes and guitars in the evenings (sometimes in the middle of the night); and most of all, tremendous friendliness and hospitality from Chileans everywhere we went.

Arica is the northernmost city in Chile, set on the Pacific coast very close to the Peruvian border and is also the main port access for land-locked Bolivia a few hundred kilometers to the east. It only rains once every few years although a moist fog (*camanchaca*) from the ocean hovers over the city, mixed with dust from the adjacent hyperarid desert. The steep mountainous desert is interspersed with tiny rivers in enormous valleys that drain distant snowcapped Andean peaks. The well-utilised rivers support highly productive olive groves and tomato fields in the valley floors; we were served fresh olives and salsa at every meal.

Calogero and Claudio were assisted with conference organisation by Lautaro Núñez, Universidad Católica del Norte, Chile; Martin Grosjean, University of Bern, Switzerland; David Thomas, Oxford University, UK; and Mike Smith. The conference was sponsored by IGCP500 (Dryland Changes: Past, Present, Future); PAGES; the Centro de Investigaciones del Hombre en el Desierto, and several other Chilean organisations. Delegates were sourced from 14 countries. Australia was well-represented, including 5 keynote addresses and 6 additional papers. The Australians, as well as maintaining a high profile at the conference, proved to be enthusiastic travellers, taking every opportunity to see as much of the Atacama Desert and adjacent Andes as possible.

Gallivanting at high altitude

John Magee, Steve Webb, Paul Hesse and I thwarted jet-lag upon arrival from Australia by hiring a Hilux in Arica and heading to the pre-cordillera and altiplano for a few days. With about six words of *castellano español* between us and much gesticulating with patient locals, we succeeded in purchasing groceries and petrol. We drove north up the Panamerican Highway then, before the Peruvian border, turned eastward onto Highway 11 which leads to La Paz, Bolivia. This road took us along the Lluta (pronounced "*yuta*") valley, past gigantic ancient geoglyphs of figures drawn in black stone placed on bare light-coloured hillslopes. The geoglyphs

Left: Tiliviche geoglyphs off the Panamericana Highway between Arica and Iquique, marking an ancient llama trade route to the coast.
Right: Pink flamingos on Salar de Atacama, a large salt lake where the thick salt crust includes rare lithium chlorides, borates and potassium salts.

are pre-Columbian in origin and are dominated by llamas (*"yama"*) that mark out important pack train routes that have only recently been superceded by the modern Highway 11. We stopped off at a famous café called 'Km 38 1/2' in the middle of nowhere. We were heartily welcomed by our English-speaking host, a Basque descendent, who told us much of the tempestuous history of the region. We were plied with plump local olives and salsa followed by a delicious lunch that included wholemeal bread just baked in a conical mud-brick oven outside, and abundant avocado. This was the beginning of two weeks of constant friendliness and hospitality and good food received from the northern Chileans.

The Río Lluta valley has a smattering of tiny, dusty mud-brick villages set at the base of bare steep hills. Each village has a small whitewashed and ornamented church as its centrepiece. At higher elevations, the villages are set on stone-terraced fields that cling to rocky mountainsides, where the economy revolves around llama and alpaca produce. Our destination was Parque Nacional Lauca in the altiplano, adjoining the Bolivian border. Here we were amidst active snow-clad volcanoes and mineral-rich lakes that have developed through damming by late Pleistocene lava flows. We observed flocks of wild vicuñas grazing on wetlands formed from snow-melt, and pink flamingos in the saline lakes. We found a perilous steep dirt road in a remote, abandoned silver mining area where only cacti grow amidst brightly coloured sulphide-rich rocks and spotted an odd vizcacha – a pudgy rabbit with a curly tail. This treacherous road descending the pre-cordillera range involved dozens of linked hairpin bends without guard-rails. Legacies of past casualties in the form of plummeted vehicles and numerous shrines to the deceased festooned the roadside. Good 4WD driving by John Magee! Upon return to sea level we enjoyed a more sedate couple of hours at the impressive Museo Arqueologico San Miguel de Azapa, located in an old olive hacienda on the outskirts of Arica.

Most noticeable in northern Chile is the pronounced vegetation zonation travelling west to east, from bare absolute desert coastward, to puna grasslands of the pre-cordillera (2000–4000 m) to high Andean steppe of the altiplano (above 4000 m), to the upper vegetation limit above 5000 m characterised by barren volcanic rock and snow. There are places in the Atacama Desert where no rainfall has been recorded for 400 years. The desert is located too far north to receive winter rainfall from the southern Westerlies, and is in the shadow of the ~6000 m high Andes which sequester any moisture arriving from the summer tropical Easterlies.

Pre-Conference Fieldtrip

The Pre-Conference excursion followed much the same route as the unauthorized version outlined above and also contained a generous complement of Australians: Heather Builth (Monash University), Matt Cupper (The University of Melbourne), June Ross (University of New England) and Mike Smith.

The fieldtrip was notable for pushing the bounds of human endurance, made all the more remarkable by the fact that we were jet-lagged to our eyeballs and hadn't obtained any sleep the night prior to departure due to a

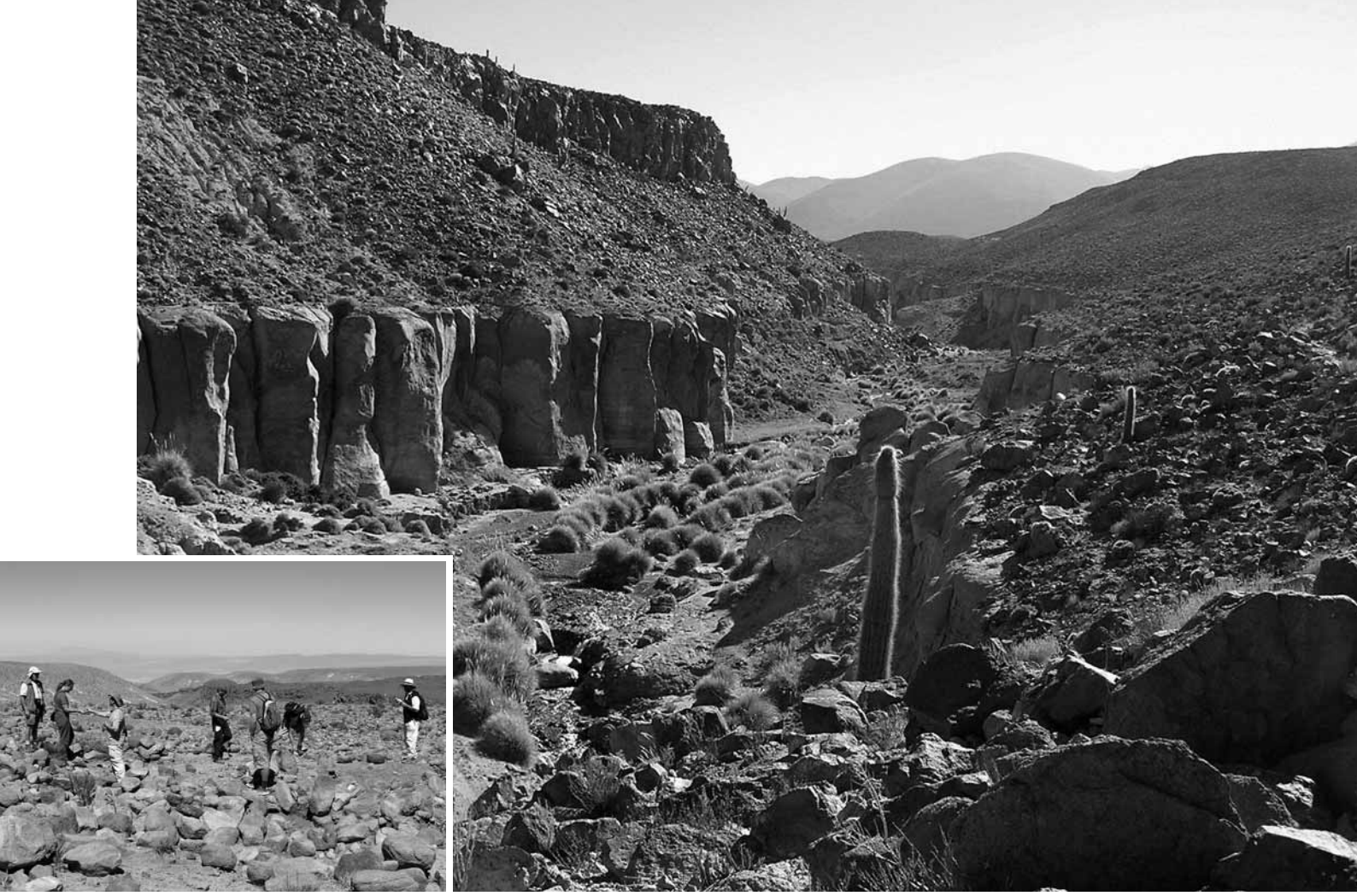
rowdy *discoteca* at the conference hotel. These activities began with squeezing one Canadian, two Germans, two Spaniards, three Chileans and four Australians into a small dingy after dark and battling the mighty Humboldt Current for 3 hours to visit a colony of hungry sea-lions.

We then drove from sea level to an altitude of 4623 m in an afternoon, whereas physicians recommend that you should acclimatize at a rate of 1000 m per day. We all began to notice the textbook symptoms of acute mountain sickness as our bodies responded to the hypoxic conditions: headaches, nausea, fatigue, dizziness, muddle-headedness and staggering gait (although of course these symptoms can all be confused with acute alcohol poisoning). Another strange yet classic physiological response was altitude diuresis, so bus stops became more frequent as our kidneys strove to dump fluid (also can be confused with excessive alcohol consumption). Fortunately, we descended to Putre at an altitude of 3500 m for the night, staving off the progression to high altitude cerebral oedema.

Next on the extreme stakes was fording the mighty Río Caquena for an illegal foray into Bolivia. Luckily there were no landmines or security forces on the border and we scampered back to Chile unscathed. We then piled back into the bus for a thirteen hour journey through rough, steep, narrow, switch-backed and safety-barrier-free mountain passes down to Codpa. Once we took a wrong turn in the dark and the road disappeared completely; another time the second bus driver had to alight and guide us over the two concrete slabs that formed the bridge over a ravine.

Of course there were many less arduous moments, including relaxing in a hacienda eating home-grown olives and enjoying the Codpa resort swimming pool. We also saw the Chilean camelid "big four": llama, vicuña, alpaca and guanaco, as well as the diminutive vizcacha, although they all taste like goat – palatability was certainly aided by sipping pisco sour (2 oz Pisco, i.e., distilled wine, 1 oz lime juice, 1/4 oz sugar, 1/2 egg white, dash Angostura Bitters).

Valle de la Luna, San Pedro de Atacama, the most arid desert in the world. The basin is bordered to the east by the puna (pre-altiplano) of the Andes.



Left: A quorum of Australian 'cacti-walkers' looking at a Holocene human occupation site in Quebrada Puripica, led by Martin Grosjean, Claudio Latorre and Calogero Santoro.
Above: Quebrada Puripica, San Pedro de Atacama, where thick relict Holocene wetland sediments are inset within the bedrock canyon.

Post-Conference Fieldtrip

A strong contingent of Australians participated in the four-day Post-Conference excursion southward to the Tropic of Capricorn and into the centre of the Atacama. The first day took us down the Panamerican Highway to the 19th century port city of Iquique with stop-offs at archaeological sites including an artifact-rich midden in the little fishing village of Caleta Camerones. The Camerones river is high in dissolved arsenic leached from ore deposits in the Andean headwater catchments and is also an area where 7000 year old artificially mummified fetuses and infants belonging to the Chinchorro people have been found. A causal link between toxic arsenic levels in the environment, high infant mortality rates from arseniasis, and the early tradition of mummification has been drawn by conference delegate, Bernardo Arriaza of the Universidad de Tarapacá. The tour took in the spectacular Tiliviche geoglyphs comprising hundreds of figures dominated by llama but with at least one pursuing puma represented. We travelled through vast distances of excavated ground where near-surface nitrate deposits have been strip-mined from putative Tertiary lacustrine environments. In Iquique we wined and dined elegantly.

Day Two took us across the coastal cordillera to Humberstone ghost town, the remains of now-gone nitrate mining heydays. Nitrate excavation and export from the Atacama ceased some decades ago with the advent of alternative compounds for fertilizers and explosives. We hiked along the edge of a nitrate-rich Tertiary palaeolake at the base of the Pintados Hills. The persistence of extensive sheets of highly soluble nitrate salts in the landscape is testimony to the longevity of extreme aridity in the Atacama. At Pintados, 355 geoglyphs cover the hillslopes, dating from around AD 500 to AD 1500. The tour route took us across a complex landscape developed on a series of graben and horst structures – depressions and mountain ranges – to the Calama Basin.

We stopped for a photo shoot at Quillaqua, a place that appears in the Guiness Book of Records as the driest on Earth. We passed Chuquicamata, the world's biggest open-pit copper mine, and nearby Calama, a fairly ugly, treeless shanty town that is burgeoning in response to expansion of the mine. Claudio took us off the beaten track to near the Rio Salado (22°S) to visit rodent midden sites from which he has reconstructed the last 22,000 years of summer rainfall variability and past plant distributions. He has matched the rodent midden palaeoclimatic reconstructions with palaeolake depth records on the Bolivian altiplano. Our destination was San Pedro

de Atacama, in the heart of the Atacama Desert. Just after sunset we drove through the Valle de la Luna, a spectacular treeless landscape of intricate serrated ridges and rills etched into saline bedrock lithologies, and then descended to our adobe lodgings in San Pedro on nightfall. The streets of the village are all flanked by high mud-brick walls with zig-zag crests, creating a rectilinear maze of lanes. Some years ago there was a tame condor in San Pedro whose wingspan only just fitted between the street walls but who flew around the village at low level anyway. One day, rounding a right-angle corner, he collided with an elderly French tourist who died of a heart attack from the shock of the encounter.

San Pedro de Atacama and surrounding smaller villages in scattered oases are settled by Atacamanean ethnic groups, descendents of Inca and Spanish ancestors. The villages encircle the Salar de Atacama, a salt lake that covers 3000 km2 at 2350 m elevation. The salar is surrounded by mountain ranges, most notably the Andean precordillera to the east. Some 14 active volcanoes are scattered along the Andes here, on or close to the Argentine and Bolivian borders; many of these are perfectly conical in form. The summits of some of the highest volcanoes, above 6000 m, retain evidence of ancient Inca presence. On Day Three Lautaro Núñez ('the John Mulvaney of Chile', to quote Mike Smith) guided us to the archaeological site of Tambillos at the edge of the salar. Here, human bones are evident amongst numerous stone tool artifacts. Villages on the footslopes of the cordillera are constructed from pink ignimbrite blocks and are typically located on canyons that receive some streamflow from the mountains. We visited Toconao village en route to the high Andean steppe where lakes Miscanti and Miniques are perched at 4150 m at the base of snow-clad volcanoes. The lake shores are encrusted with bitter salts, products of mineral-rich runoff from the volcanic rock plus high evaporation rates. A 22,000 year sediment and pollen record of climate change has been documented from the lakes (e.g., Grosjean *et al.* 2001, *Glob. & Planet. Change* 28: 35-51), attesting to a history of numerous drying and wetting cycles, abrupt and high amplitude changes in effective moisture, and century-scale lags in vegetation responses. After descending from the high lakes and lunch in the village of Socaire, the party split into two groups. The archaeologically-minded delegates visited agricultural oases in canyons and anc-ient villages whilst the environmentally-minded visited Chaxa brine lagoon in the Salar de Atacama to witness the impressive salt crust and pink flamingos. There are even camouflaged lizards that are a dappled white colour and perfectly at home living in hollows in heaved salt crust. Brine shrimp and phytoplankton are the main food source for birds and reptiles inhabiting the salar.

Our final day again split the party into two groups. Under the guidance of Lautaro, the archaeologists visited sites at Tulor, Quitor and Catarpe, and the excellent museum "Padre le Paige" in San Pedro de Atacama. Five Australians (Kat Fitzsimmons, ANU; Matt; Paul; John and myself), led by Martin, Calogero and Claudio, opted for a hike up Quebrada Puripica in hills to the north. This canyon, at around 3600 m, is incised into pink ignimbrite and receives a small stream of melt water from the altiplano. A basalt flow caps the northern rim of the canyon. The steep rocky slopes are studded with pencil cacti (*Echinopsis atacamensis?*) growing several metres tall. A distinctive feature of Puripica is a relict 3–20 m thick unit of middle Holocene wetland deposits perched within the canyon. This palaeo-wetland unit is correlated across different geomorphic settings at the base of the Andes and relates to elevated groundwater levels at the time of deposition. The fine-grained wetland sediments are now incised and the present-day stream flows over water-worn bedrock in the bottom of the canyon. The origin, depositional environment and palaeoclimatic significance of the wetland unit is controversial and currently under debate (e.g., Rech *et al.*, 2002, *GSA Bull.*, 114/3: 334–348; Grosjean *et al.*, 2003, *Palaeo*^{3} 194: 207–222). Although at Puripica the relict wetland deposits are Holocene in age, the setting is in some ways analogous to the enigma of a late Pleistocene wetland in Brachina Gorge in the Flinders Ranges, South Australia (Williams *et al.*, 2001, *Quat. Int.* 83–85: 129–144). Numerous Holocene human occupation sites are scattered along Puripica canyon, with large quantities of basaltic grinding stones festooned across the landscape. There is even an irrigation channel of unknown antiquity made of rocks and carbonate cement clinging to the upper canyon wall. We all regrouped in San Pedro de Atacama in the late afternoon, bade farewell to our hosts, and returned to Calama for evening flights to Santiago. During a stop-over in Antofagasto on the coast, where Calogero was disembarking, he took charge of the LAN Chile flight intercom before exiting the plane to make the following announcement to all passengers: "OK you desert lovers, see you in the Kalahari in 2008, hasta luego."

Next...

The Chile conference is to be followed up by a 3rd Southern Deserts Conference to be held in either the Kalahari or Namib deserts in September 2008 (in Namibia or northwestern South Africa) under the auspices of IGCP 500. For further information nearer 2008 (i.e., after the dust of the XVII INQUA Congress in 2007 has settled): igcp500.ouce.ox.ac.uk.

Greenhouse2005:
Action on Climate Change

Melbourne, 13–17 November 2005

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Greenhouse2005: Action on Climate Change covered a range of topics from science and modelling to national/international strategies of adaptation and mitigation. Speakers framed their inputs from scientific, policy and industry perspectives. There were ~100 individual presentations, and speakers included the Governor-General, the Federal Minister for the Environment and Heritage, the Victorian Minister for the Environment, scientists (predominantly from CSIRO), and representatives from several state government departments, industry and NZ/UK governments.

Some of the key points raised at the Conference were:

1. Climate science – complexity, extremes and uncertainty It was argued that, '... the scientific evidence for climate change is compelling' (Greg Ayres – Chief of CSIRO Marine and Atmospheric Research) and that, '... climate change is the biggest environmental issue facing Australia' (Senator Ian Campbell – Federal Minister for the Environment and Heritage). Comments made at this conference by the Governor-General and the Federal Environment Minister reflect an increasing acceptance of the risk of climate change in Australian goverонment power structures. Nevertheless, the complexity of the issue appears to have deferred policy development and implementation in some areas and this delay may prove detrimental in the future.

Many talks outlined the observed changes in the last few decades (such as the melting of ice caps, rising sea levels, higher temperatures of droughts, increase in Southern Ocean temperatures, species loss, changes in plant flowering times and migratory bird arrival dates, observed thickening of woody vegetation, 2005 will probably be the warmest year on record, etc). However, it was acknowledged that the climate system is very complex and there is much uncertainty about future impacts. Geoff Love (Director of Meteorology, Bureau of Meteorology) suggests that the biggest scientific challenge in the climate change field is understanding the effects of clouds (for modelling outputs). Other major scientific challenges and key research areas include: atmospheric chemistry, global energy/moisture budgets, sea ice, and sea level rise.

It was also argued that some changes are certain and inevitable due to the lag effects of CO_2 in the atmosphere, '... climate change will happen regardless of mitigation' (Blair Fitzharris, University of Otago). For example, a 1-2° C rise in temperatures is certain, thus adaptation measures are necessary and important in addition to mitigation measures (Greg Ayres, Graeme Pearman). Potentially vulnerable areas identified include: rainforests, fresh-water wetlands, coral ecosystems, coasts and alpine regions.

It was noted that important and little understood areas in climate change science and policy are climate extremes, abrupt events, 'dangerous' climate change and the importance of these for human systems. The importance of thresholds, feedbacks and trigger points (including human activities) in natural systems was briefly touched upon, e.g. the disruption of the thermohaline circulation system in the North Atlantic and its global ramifications.

In the only panel session of the entire four day conference containing palaeodata presentations, Kate Harle (CSIRO Sustainable Ecosystems) waved the flag for Quaternarists. She highlighted to the audience (of which the majority were non-palaeoscientists) that palaeodata can help elucidate past climate variability and natural climate cycles, their past impacts and the possible drivers of climatic changes. She noted many of the key drivers of climate including solar activity, Milankovitch cycles, asteroids, volcanoes, ocean circulation patterns and that evidence from palaeostudies has revealed rapid warming events in recent geological history (e.g. up to 7°C in 20 years). However, she argued that the current interglacial period is comparatively stable in comparison to glacial periods, and that current climate change is likely to be driven by factors outside of the natural cycles, i.e. human activities.

2. Public opinion, communication, and awareness The importance of communicating the risks posed from changes in climate was stressed throughout this conference, and the choice of words used for this is important. For example, Steve Hatfield Dodds (CSIRO Social and Economic Integration) argued that environmental scientists can learn from social scientists about human behavioural responses and what type of communication is likely to be more effective. He suggested that there is a big difference in public perception (and likelihood of action/uptake) between presenting the economic effects of mitigation measures as either a 'cost' or a 'foregone gain'. People are naturally adverse to loss so we need to frame education/awareness campaigns as a 'foregone gain' rather than as a 'cost/loss'.

There was a general call for increased communication between scientists and policy makers. In particular, scientists need to increase their sense of urgency in communicating science to the public and decision makers.

*3. **Importance of a risk management approach*** One of the main themes was a general suggestion for scientists to present scientific results in terms of risk (probability x consequences) rather than the emphasis on uncertainties and wide ranging scenarios. It was argued that we do not need conclusive science before action needs to be taken; a sufficient probability of occurrence and magnitude of impact justifies a prudent risk management approach. It was suggested that we already have enough information to manage climate change as a risk, and that a modified version of the Australian Standard for Risk Management (AS4360) can be used to manage uncertainty and risk.

*4. **Leadership/policy certainty*** Many argued (including industry) that governments must show greater leadership and commitment, with both policy and legislation. Government should be strategic, not just tactical or political. Industry and businesses are becoming increasingly aware of projected climate change impacts and increasingly willing to act, but currently lack direction and policy certainty from government.

This conference also highlighted the different national policy responses between the Australian, New Zealand and UK governments. Although Senator Ian Campbell (Australian Minister for the Environment and Heritage) acknowledged that, '... expanding energy use and reducing greenhouse gas emissions is the biggest policy challenge facing the world', he argued that he was glad the debate has moved beyond Australia's non-signing of the Kyoto Protocol and noted that even supporters of the Protocol such as Tony Blair have recently acknowledged its flaws. In stark contrast, Bill Bayfield (General Manager of Sustainable Industries and Climate Change Group, NZ Ministry for the Environment) highlighted that New Zealand is already using renewable energy sources for up to 70% of their needs, and explained that although New Zealand is having difficulties meeting its Kyoto targets, they felt it was important to sign as a member of the international community and that it might provide them with access to new technology. Chris Leigh (Head of the National Climate Change Policy Division, UK Environment Department) also gave an insight into mitigation policies within the UK, which include emissions trading schemes, energy levies and agreements, renewable energy targets and incentives, a carbon trust for research programs, energy efficiency legislation, etc.

It was pointed out that some of the best policy initiatives on climate change action are happening at the state level in Australia. It was suggested that the most important policy initiative is for states to work together to develop a national carbon emissions trading scheme (John Thwaites – Minister for Environment, Victoria). (Note: The NSW Premier Morris Iemma announced 2 weeks after this conference that he has requested the Prime Minister to convene a National Summit on Climate Change and Emissions Trading, and if not, then the States and Territories should go it alone).

*5. **Solutions – mitigation and adaptation measures*** There was general agreement that there is no 'silver bullet' solution to this problem and that there is a need for both mitigation and adaptation measures, which should be seen as complementary rather than as alternatives. Options include demand management, solar, wind and nuclear energy, fuel switching, increasing energy efficiency, carbon trading, full cost recovery planning, sequestration, etc. It was stressed that every technology has economic implications and social issues, thus, no one technology alone will be enough – a combination is needed.

Palaeo-studies and current climate change policy and research directions

The increasing scientific, government and public concern over the issue of climate change provides a real opportunity for palaeoscientists to play a prominent role in the mainstream policy development around this issue. Palaeoscientists have a unique understanding of and perspective on the issue of future climate change. The increasing body of scientific literature/opinion on the projected magnitude and rate of future changes means that we are being urged as scientists to increase our communication with both the public and decision makers about our knowledge and expertise on this issue. A good example is the web forum at 'www.realclimate.org', which is doing a great job to raise the profile of climate science.

Perhaps the need for more involvement of palaeoscientists into the mainstream climate change issue is best illustrated by the answer to the following question asked at the Greenhouse2005 conference. After a talk on climate change and the need for 'long term' rather than 'short term' investment, the question of what is the definition of 'long term' was asked. The answer: 10 years.

Unfortunately, the above is not an isolated view. Key research priorities and directions for climate change impacts research are being set by government policy makers where the words 'monitoring' and 'evaluation' are used as catch phrases and 'long term' data sets are barely more than the length of a few El Niño cycles. We, as palaeoscientists, recognise and understand that long term means more than 10 years.

The opportunity is there for us to take.

Constructing Fire Histories

A workshop on techniques and approaches to reconstructing past fire events

Archaeometry Conference, Canberra, 12–15 December 2005

Simon Haberle

As part of the recent successful Archaeometry Conference, held in Canberra between the 12th and 15th December 2005, a dedicated symposium and follow-up workshop on "Constructing Fire Histories" attracted a large contingent of charcoal buffs. A total of 16 oral presentations (seven from PhD students) and three posters were presented exploring the range of traditoional and emerging techniques available to reconstruct past fire regimes. These include the analysis of small fragments of charcoal preserved in sediments in archaeological and palaeoecological (lakes and swamps) contexts, fire-scars within tree-rings, historical records of fires and modeled simulations of past fire events. Researchers within these different disciplines often encounter common problems of analysis of charcoal and its interpretation as a fire event, and yet they have largely worked in isolation from each other.

The oral presentations and posters brought together people working within these fire history disciplines to present a "state-of-play" assessment of individual areas of research. The follow-up workshop provided the opportunity to identify uncertainties and commonground that exist in efforts to define, quantify and interpret charcoal in the palaeo/archaeological record. Major outcomes of the session and workshop were:

- Exposure of young researchers in each discipline to the major issues across all areas of research.
- A synthesis in understanding the major scientific problems in definition/quantification/interpretation faced by each discipline with regard to charcoal and its relation to past fire events.
- A better understanding of the traditional as well as emerging techniques and the ways in which these might be adapted for use in other disciplines.

The wrap-up discussion looked at the possibility of development of a network of expertise around key areas of high research potential in constructing fire histories. The Atherton Tableland, Victorian Highlands and Tasmania were considered areas of high potential.

I would like to thank all the participants for contributing to a very productive two days and the ARC Network for Earth Systems Science for sponsoring all the PhD students to attend the meeting. Also, congratulations to Simon Connor (University of Melbourne) for his award for one of the best student paper presentations at the conference. Abstracts and an outline of the fire workshop can be found at: *http://palaeoworks.anu.edu.au/news.html*

Uncertainty is inevitable but risk is certain

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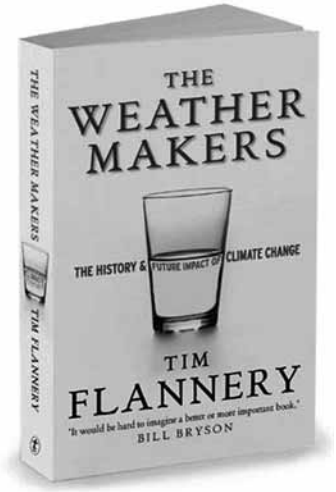
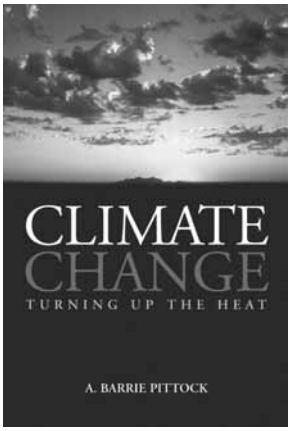


Tim Flannery
The Weather Makers: The history and future impact of climate change
Text Books, paperback,
AUD$32.95, ISBN 1920885846



A Barrie Pittock
Climate Change: Turning up the heat
CSIRO Publishing,
paperback, AUD$39.95
ISBN 0643069313

Although they were published at almost the same time and deal with the same subject matter, *The Weather Makers* and *Climate Change* are two very different books. Contrasted, they highlight some of the snakes and ladders of the populist science approach and the more scholarly textbook approach.

The Weather Makers is the result of a recent epiphany of the author, Tim Flannery. Formerly he was not unduly concerned about the changing greenhouse effect, considering climate change to be a fascinating but largely academic part of Earth's past, most useful for understanding why environments are as they are now. After contact with Steve Schneider and other climate change scientists he concluded that greenhouse-induced climate change is the most urgent issue facing the Earth's, and humanity's future.

Flannery is a good writer and has succeeded in bringing the past to life in a number of books dealing in historic and pre-historic accounts of environmental change. The *Future Eaters* was an iconic book that contrasted Australia's environmental future with its past, suggesting that Australians are exceeding the nation's carrying capacity, and exhorting us to forge a better understanding of our environment and how we may live within it. *The Weather Makers* is cleverly titled with the same meter, suggesting an oeuvre where Flannery develops and expands a body of environmental thought in successive volumes.

As there have been many books on climate change by both specialists and general science writers, how does *The Weather Makers* compare? It has attracted a series of positive reviews in the media, lauded by figures such as Bill Bryson, Ian Lowe and Jared Diamond. The book itself contains some 300 pages of text in open font and is easy to read. It contains a forward and five parts.

Part One describes the climate system from a Gaian perspective. The development of scientific understanding of climate is described in eight chapters finishing up with the geological formation of "buried sunshine" and its exhumation to provide us with light, heat and motion. Part Two describes observed impacts on a range of systems, mainly natural, with some prognosis of how those systems may be affected in the future. Part Three describes the modelling of future climate and impacts. In parts One to Three, I have issues with inappropriate use of metaphor, and poor communication of uncertainty, and loose interpretations of the state of the science, especially with the attribution of impacts. Parts Four and Five are about current and future policy, where Flannery's more cautious approach to these subjects saves the book and offers genuine relevance to popular discussion on climate change.

Part One opens by contrasting the Gaian approach with reductionist versions of science, suggesting that even if the Gaian hypothesis (as proposed by James Lovelock) cannot be validated directly, it serves as a useful approach to describe climate as opposed to reductionist descriptions. However, there is no need to resort to an ersatz version of Gaia when science and mathematics provides rigorous descriptions of complex adaptive systems and their dynamics. It is possible to use an internally consistent set of metaphors to describe climate within a holistic structure, but Flannery does not do this. Part One is described as "Gaia's Tools" and, disappointingly, Flannery utilises a range of disconnected metaphors throughout the remainder of the book that belies this approach.

Part Two is a Hanrahanian litany of impending doom. Of the impacts discussed, some can be ascribed to greenhouse climate change with high confidence; others may be caused either by climate change or ongoing natural variability; or for a few impacts (e.g. disease factors in frogs), climate change may not be involved except as a secondary factor. However, they are all lumped together. This may not matter if one is assessing current vulnerability, but it does matter when attributing change and predicting whether that change is likely to continue. Because the book is discussing the future

impacts and vulnerability to climate change, this lack of distinction seems careless. However, where Flannery describes impacts that he has observed personally, such as the loss of cloud forests on tropical mountains, the language shines. It is lyrical, heartfelt and has an impact on the reader.

Inappropriate metaphor opens Part Two where we are asked to imagine "magic gates", which are thresholds, or tipping points, representing abrupt change in a complex system. Magic gate is a terrible metaphor. The usage of the term magic implies that these shifts are occult or unknowable, whereas the role of science is to understand and explain such phenomena. Are such gates magic until they are explained or do they remain magic after the mystery has been solved?

Magic gates are used to describe large-scale climate 'jerks' in 1976 and 1998, implying that the Earth passed through two greenhouse-related shifts at those times. Here, climate is described as being telekinetic rather than teleconnected. The former refers to movement occurring at a distance from the source, the latter means simultaneous movement occurring across large distances. The 1976 climate shift, measured through widespread phenomena in the Pacific Ocean, marks a shift between La Niña and El Niño dominated regimes as part of quasi-periodic decadal oscillations in the Pacific. Certainly, it occurred on a pattern of global warming, but was it a greenhouse phenomenon in its own right? The literature is almost silent on this issue, unlike this book. It is likely that the 1976 shift was one of many such events in a long history of climate variability. Likewise, the 1998 El Niño was probably no "magic gate" but was an extreme event that caused, as Flannery recounts, a number of irreversible impacts and may have been linked to a shift in climate states oscillating on a decadal timescale. The main point is not that climate was pushed into a new greenhouse-induced state, as implied, but that climate variability occurring on an underlying trend will push systems to new extremes, threatening their ability to cope.

Part Three on the Science of Prediction is also careless in its approach. A recent (2005) upper estimate of sensitivity of 11.3°C for double CO_2 warming is explained as an unprecedented estimate, despite this figure being exceeded by a handful of papers dating back five years. On Page 161, the difference of 5°C between the last glacial maximum and the Holocene following a rise of 100 ppm in CO_2 is explained as an anomaly compared to model projections of 3°C following anthropogenic doubling (a rise of about 260 ppm CO_2). This anomaly is explained through the blocking of sunlight by aerosols, and Flannery speculates that if aerosols were removed, then the earth may experience a runaway greenhouse effect. However, following the last ice-age, the melting of large ice-caps and snow changed the global average albedo considerably, contributing to much of the subsequent estimated average global warming of 5.0°C. For someone who has written extensively on ice-age environmental change, this is a major omission. The post-glacial 100 ppm increase in CO_2 only partially contributed to that warming of 5°C and that part was likely to have been relatively small. The issue of so-called global dimming, where aerosols suppress warming by blocking sunlight, is real but the warming response if aerosols are removed will not be as large as implied by Flannery because he has overlooked the ice-albedo effect that influenced post glacial climate sensitivity.

Many of the statements in the book are contestable. On Page 165 it is suggested that short-term climate predictions are less certain than long-term predictions, the opposite of what is true. On page 168 it is suggested that scientists say that a 70% reduction in greenhouse gases by the mid 21st century from 1990 is required, which is true only for developed countries, and the global average is closer to 45%. On page 169 it is suggested that 5 cm of global sea level rise is dangerous. On page 179, it is suggested that temperature in Australia may rise up to 2.5 times the global average, based on research published in 1992, which is certainly given no credence today.

Chapter 19 deals with the modelling of bioclimatic envelopes. This is a statistical construct that explains the current distribution of an animal, plant or community in climatic terms. It describes the ecological envelope, or where each organism can exist under normal environmental conditions. Larger than this is the physiological envelope, where the organism can survive but may not be able to freely reproduce. However, many weeds live in climates that exceed their original ecological envelope, as do many animals and plants raised artificially.

Frustratingly, Flannery dooms every plant or animal that has its ecological envelope exceeded under climate change, to extinction. Instead of promoting the precautionary principle, which states that a lack of full scientific knowledge should not be used to delay action, Flannery uses the precautionary conclusion, where the outcome is forgone, even though the analysis is incomplete.

The largest error in the book concerns Flannery's treatment of adaptation. Adaptation is complementary to mitigation – it is not in competition as implied on pages 207–8. Mitigation lowers the upper limits of potential warming – there is no way that even rich societies will be able to comfortably adapt to changes of say, 4°C to 5°C, by 2100. Adaptation will be needed to cope with climate change that will occur in any case. At minimum, societies and environments need to adapt to change climate change already experienced and will need to deal with the impacts accompanying at least another 1.4°C warming by 2100. Ironically, the greatest demand for adaptation will come from those who have the least capacity to carry it out – those in least developed countries, especially those who are vulnerable to existing climate variability. Instead Flannery refers to Aubrey Meyer who likens adaptation carried out by those who can, if used as a substitute for mitigation, to genocide. Adaptation is not mentioned in the remainder of the book, which exclusively deals with mitigation.

This overlooks the valuable work done over the last decade to place adaptation within a human development context. The model used by Flannery is discussed by Pittock in his book where in the North (developed countries) climate change is largely seen as an environmental problem that can be solved by the allocation of mitigation targets whereas in the South (developing countries), climate change is largely seen as a human problem that has to be responded to. It is in the latter area where equity arguments can be used to greatest effect.

Even though adaptation is omitted from the solutions outlined in Parts Four and Five, these sections are much better than

the previous two. The language is more moderate, perhaps because here the author moves beyond his core skills and treats the subject matter with a great deal more caution. Interestingly, given the absolutist tones of the previous two parts, the impact is not lessened. The discussion in these sections is well outlined and accessible given the complexity of the response that is required. The discussion on nuclear power, which has attracted so much attention in the press, is presented in a sober and matter-of-fact manner, with Flannery suggesting that all options be examined, rather than advocating it in particular.

The index is poor and the referencing not particularly rigorous.

The major reason why I am so critical of this book is because of the recent success of Lomborg's *The Skeptical Environmentalist*. Like *The Weather Makers*, the *The Skeptical Environmentalist* is a polemic rather than a work of science, written to promote a particular view. Lomborg did two things that have raised the bar for all authors that follow. He created a straw man out of the sloppy use of statistics by environmentalists and proceeded to demolish it. He then used similarly sloppy statistics, partial analysis and half truths to create a seductive message that appealed to political conservatives who wanted to hear that business as usual applied with a light tinge of green would deliver the appropriate environmental outcomes (I am not accusing Flannery of equivalent sins, but he has been remiss in his use and interpretation of the science). Having demolished the opposition and salved any residual guilt in one well-written and extensively footnoted tome, many of the policy options espoused by Lomborg were rapidly adopted by political conservatives. Likewise, *The Weather Makers* may appeal to those with an overall environmental outlook who are looking for an accessible entrée into the issues of climate change, but it is not likely to appeal to those with a more sceptical bent. I think to appeal to the audience beyond true believers, or potential true believers, writers have to rise to the challenge posed by the success of Lomborg's book and combine accessible writing with greater rigour.

I'm also not convinced by the use of shock and awe tactics in environmental writing. My view is that global climate change is so serious there's no point in exaggerating it. People tend to 'freeze' or turn off if the issue is too large and seems intractable. The feedback I get from audiences I speak to is that the conservative, scientifically established version, with fully outlined uncertainties, is scary enough. If the whole book was delivered in similar tones to the last two parts it would have been much better.

In conclusion, *The Weather Makers* is an accessible but flawed book which, despite its broad coverage, is a committed polemic rather than a work of science. Many of the conceptual models used by the author are out of date, and it's a pity he did not consult with the many people who have been endeavouring to improve these concepts. I hope that Flannery continues to learn more about the complexities of climate change issues and communicate them, because his voice in the debate is likely to be influential.

Turning up the Heat is a very different book. At 316 pages it is of a similar length to *The Weather Makers*, but with a small, closely spaced font, it is perhaps half as long again. A Foreword for the book has been written by Dr Rajendra Pachauri, Chairman of the Intergovernmental Panel on Climate Change (IPCC). A. Barrie Pittock is the pioneer of climate impacts, creating the Climate Impact Group with the then CSIRO Division of Atmospheric Research in 1990 and running it until his retirement in 2002. Since retirement, Pittock has been involved in a summary of Australian climate impacts for the Australian Greenhouse Office. He is currently writing a book on his involvement with Aboriginal issues on the 1960s and 1970s.

The coverage provided by Pittock is similar to that in *The Weather Makers* but the aim is to provide an accessible account of the science that convinces the reader that urgent action on climate change is needed. One of Pittock's aims is to convince those who are sceptical of the science or who believe the policy risks of acting are greater than those posed by climate change.

The reader needs to work harder to read Pittock's book. The language is less accessible and generally fairly dry. The reader also requires a basic knowledge of science, although all specialist terminology and climate-related concepts are explained, and explained well, in most cases. There are a number of useful charts and diagrams in the book but these require sufficient experience from the reader to be able to interpret them.

In general, the book provides a valuable update on the IPCC's Third Assessment Report (TAR), but relies a little too much on it for my liking, given that the TAR was released in 2001. However, the newer science is well covered, with important new information on large-scale singularities such as the potential collapse of the thermohaline circulation and the Greenland and West Antarctic Ice Sheets. As such, it stands as a good signpost situated two-thirds of the way between the IPCC Third and Fourth Assessment Reports (the latter due in 2007).

The balance between the natural environment and human systems is also much better achieved, with important updates on a range of projected regional impacts and development profiles. The basic synergies between adaptation and mitigation are explained as are many of the aspects of adaptation and adaptive capacity that have been developed since the TAR. For example, adaptive capacity, which is the capacity to adapt in response to perceived or experienced climate change, is also critical to other concerns, such as the Millennium Development Goals.

Equity is also an importance principle in applying climate change policy. Pittock discusses the growing emissions of developing countries and their articulation of their rights to develop in order to achieve better lifestyles for their populations. Of course, the non-inclusion of growing developing country emissions in the Kyoto Protocol is one of the stated reasons for Australia not joining the Protocol. Pittock outlines the argument as to why he believes this stance is incorrect. The chapters on international concerns and national interests and on greenhouse politics are thorough and accessible. The sections on politics, contrarianism and policy also cannot be found in any official publication. Most books on climate change strong on policy are usually weak on the science, making this book particularly valuable.

Discussion of mitigation in both books is detailed, but neither book is able to prioritise these measures, to outline how much of the potential effort may be due to one source or another, and this is an area that requires a great deal more

research. While *The Weather Makers* is more a call to action, Pittock examines a range of technical and policy options. He also explores the requirement for stabilisation, suggesting that to avoid warming of up to 2°C from pre-industrial times with any confidence, a stabilisation of 450 parts per million CO_2 equivalent in the atmosphere may be required. Given that we currently have 380 ppm with additional loadings of other greenhouse gases, this would likely require removal of CO_2 from the atmosphere at some future stage. Currently, there is no established roadmap for getting to 450 ppm CO_2 equivalent or the somewhat more economically tolerable 550 ppm CO_2 equivalent.

The one major omission from the book is the lack of referencing in the text, largely due to space restrictions. This is compensated for by a comprehensive index, reading list and online notes at *www.publish.csiro.au/pid/4992.htm.* Those wanting to source the main references used by Pittock will find details in the online notes. The book will become a very valuable source for students, policymakers and planners who want a thorough and relatively concise treatment without having to wade through the hefty IPCC reports, which Flannery accurately describes as being as dull as dishwater.

These books are very different and there is a role for both. However, *The Weather Makers* begs the question "Is it necessary to unduly compromise the science to come up with a readable and accessible approach?" I think not, but am perhaps being too strict. Flannery's book is the more readable of the two but falls short in a number of areas. If it encourages people to better understand the issue, it will have served a valuable purpose but they will need to read Pittock's book to get that understanding. *Turning up the Heat* is the better book but will be read by fewer people. However, if some of the more sceptical readers are persuaded into action because of the arguments presented, then all the better. For the professional user, it is a valuable source of information on climate change that is both wide, and sufficiently deep.

Declaration of Interest: I have worked closely with Barrie Pittock since 1996 but have tried to be as objective as possible in this review.

Understanding a low, flat arid and old landscape

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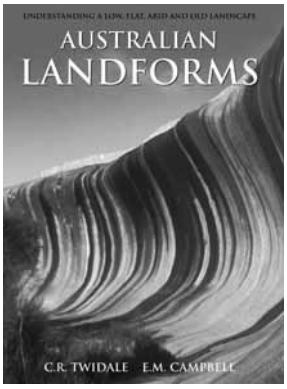

Twidale, C.R. and Campbell, E.M.
Australian Landforms: understanding a low, flat, arid and old landscape
Rosenberg Publishing,
paperback, 336 pp. AUD$59.95
ISBN 1 877058 32 7

If you move from London to Perth and you are interested in geomorphology, you have to learn to understand and interpret a landscape completely different from that in which you grew up. Before coming to Western Australia in 1988, I had rarely seen a landscape more than 15,000 years old; while the older landscapes I knew had mostly been affected by periglaciation. I now work in that part of WA where the thinnest skim of unconsolidated Cenozoic alluvium/colluvium overlies Archaean shield rock and the Geological Survey thinks that, apart from *in situ* weathering, there has been little geomorphological change since the K/T boundary! Indeed, according to the book that is the subject of this review, some of the river valleys probably formed some 130 Ma. Short of migrating to Antarctica or far eastern Siberia, a bigger geomorphological difference than that between the domesticated landscape of southern Britain and the degraded Rangelands on the Yilgarn Craton would be hard to imagine.

Naturally, I sought advice as I struggled to understand a landscape where nothing much seemed to have happened for aeons; but rivers that rarely flowed ran through enormous valleys that had clearly carried large volumes of water in the past. I do not remember who introduced me to *Australian landforms: structure, process and time* (1993), the first edition of this book, but I am eternally grateful to them. It became my bible, especially the sections on granite weathering. I jumped, therefore, at the chance to review the second edition.

It is truly a new edition, not merely a reissue of the original text with the addition of colour plates. In 1993, the aim of the authors was to write a textbook on Australian geomorphology that explained the uniqueness of much of the Australian landscape to upper Secondary and Tertiary students. While *structure, process and time* amply fulfilled that aim, *understanding a low, flat, arid and old landscape* is in many, but not all, ways a great improvement.

Structure, process and time was rather 'hard going'. Cover aside, all illustrations were in black and white, making the structural detail in some photographs difficult to see; while the B4 format meant that some illustrations were too small, although the book was very portable, if rather heavy. Each chapter concluded with an Essay, in a smaller font, in which an example of the chapter topic was discussed in some depth, followed by a list of references relevant to that chapter. It was clearly a textbook.

Understanding ... landscape is A4 and even heavier than *structure, process and time*. While still a textbook, it is much more visually attractive, although less user-friendly in some ways. It certainly could be, and in my case has been, taken into the field, but is scarcely something one wants to carry in one's backpack all day! It is also less clearly laid out than *structure, process and time.* It is printed double-column and the text has been wrapped around the illustrations, which are also mostly double-column. They are now mostly in colour and have been grouped several to a page, often back-to-back.

The B4 format of *structure, process and time* meant that illustrations could be inserted between paragraphs, or relegated to adjacent pages. The formatting constraints in *understanding … landscape* mean that some illustrations appear out of sequence, sometimes pages away from the text to which they relate, meaning one has to flip pages. When reading *understanding … landscape*, it is essential to note the numbers of the relevant illustrations, or one can get lost. That said, to have so many colour illustrations is an enormous bonus. Comparison of the two editions shows that colour greatly enhances one's understanding and appreciation of many of the illustrations, although I was intrigued to note that some have been reversed. Unfortunately, the few black and white illustrations appear to have been scanned rather than reprinted from the original negatives and are noticeably less clear than they were in *structure, process and time.*

Both books follow the same layout: introduction; tectonics: structure and relief, plate tectonics, volcanoes, folds and faults; water: weathering, mass movement, rivers, fluvial landforms; structure: sedimentary terrain, passive fractures, karst, pseudostructures; rivers: fluvial models, denudation, stream classification; the last 2 Ma: Quaternary, cold climate landforms, deserts, coasts, humans as geomorphological agents; conclusions. Each chapter in *understanding … landscape* is still followed by an Essay, but some have been changed or updated. For example, Essay 3 now analyses the north Indian Ocean tsunami of 26 December 2004; while those on Uluru, floods and sedimentary terrains have been revised. The essays are now printed in the same font as the general text, but on grey backgrounds, making them easier to read; while the references have been revised and concatenated, although comparatively few new references have been added. The most recent date to 2003. The chapter to which each source principally refers is indicated.

Comparison of the two editions shows that some chapters have been reproduced almost verbatim; others have been completely restructured with sections reorganised or rewritten. For example, pingoes have been transferred from cold climate landforms, where I feel they belong, to pseudostructures. Most of the in-text discussion in the first edition of evidence from countries other than Australia has disappeared from the second edition, which is tightly focussed on Australian landforms. Finally, features with Aboriginal names, like Kata Tjuta, are now referred to by them – a welcome change from the first edition.

As we all know, a quick way of assessing any book is to read the sections about which you think you know the most. If they seem to be adequate, then probably the whole book is equally reliable. How does *understanding … landscape* measure up? The chapter on the Quaternary is one of the least satisfactory. It is also the shortest! The references cited are over 20 years old. I suppose, given that the authors' focus is geomorphological and weathering processes predominated, even in the Quaternary, since most of Australia was untouched by glaciation, the last 2 Ma is the least interesting part of the history of Australian landscape development. The other chapters in the final section are more up-to-date. That on human effects, which focusses on salinity, is particularly good.

So, who will use *understanding … landscape*? The authors claim that, like *structure, process and time*, it is aimed at upper Secondary and Tertiary students, but at $60 few high school students are likely to buy *understanding … landscape.* More's the pity, for it is clearly and simply written and would be very useful to all Earth Sciences students. University staff teaching Earth Sciences are encouraged to persuade their libraries to buy it and *to recommend it to at least their first- and second-year students*. It provides a thorough basis to help them understand the uniqueness of the low, flat, arid, old landscape that is Australia.

Fluvial tufas of the monsoonal tropics

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Tufas are ambient temperature freshwater calcium carbonate deposits that are an important archive of terrestrial palaeoenvironmental information. This is primarily because they are strongly affected by climate, which influences the tufa system via its biota and physicochemical processes. Because of this link to regional climate, fossil tufas have been used to successfully investigate climate histories at many locations throughout the world and to provide an environmental context to important archaeological and palaeontological sites. Environmental models have great significance in the investigation of fossil tufas and they are the main focus of this thesis.

It is crucial that appropriate models are used to ensure accurate environmental reconstruction. However, no previous model has been based on tropical monsoonal tufa systems. Tufa deposits in the monsoonal tropics of northern Australia are influenced strongly by perennially warm water temperatures, high evaporation rates, and high-magnitude floods. This combination contrasts with the environmental conditions of the cool temperate and warm semi-arid sites on which current environmental models were based.

This thesis presents an environmental model that will aid interpretation of fossil tufas throughout monsoonal Australia. In the Barkly karst, northern Australia, tufas form in dam, cascade and pool/waterhole geomorphic environments. Each environment is represented in the rock record by a specific combination of tufa geomorphic units and facies associations. Preservation of particular tufa facies is thought to reflect the strength of monsoonal floods. A strong monsoon is represented by an abundance of flood indicators such as the allochthonous phytoclastic, lithoclastic and intraclastic tufa facies. Conversely, evidence of weak monsoons or a prolonged absence of floods may include oncoids, calcite rafts and thick accumulations of fine carbonate sediments. The history of the Australian monsoon is not fully understood. However, fossil tufa deposits have been preserved throughout northern Australia and hold great potential for reconstructing the region's climate history. Fossil tufa sequences at two Barkly karst sites have been interpreted using the new model. It can be applied to other Barkly karst fossil tufas as well as those in similar environments elsewhere in the world.

Isoleucine epimerisation and stable isotope ratio studies of cassowary, megapode and *Aepyornis* eggshells: biogeochemical and palaeoenvironmental implications

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Previous researchers have used the extent of isoleucine epimerisation and stable carbon, oxygen and nitrogen isotope ratios of ostrich (*Struthio*), emu (*Dromaius*) and *Genyornis* eggshells to provide geochronological control and palaeoenvironmental information on the Quaternary sequences from which these sample types are recovered. This thesis expanded this field of research by examining isoleucine epimerisation and the stable isotopes ratios of cassowary (*Casuarius*), megapode (principally the Australian brush-turkey, *Alectura lathami*) and *Aepyornis* eggshells. The aims of the research were to (1) increase our understanding of the ancient habitats of *Casuarius*, megapodes and *Aepyornis* in order to provide information on how these ecosystems functioned, as well as the nature and timing of the environmental change they have experienced, and (2) to document the amino acid and stable isotope biogeochemistry of avian eggshells in novel contexts in order to better understand the processes that influence these attributes.

Samples of *Casuarius*, *Alectura lathami* and *Aepyornis* eggshells were heated at high temperatures (110, 143 and 160°C). These experiments were used to determine the temperature sensitivity of isoleucine epimerisation in these eggshell types, expressed in terms of Arrhenius parameters, and to characterise the thermal stability of amino acids. In the stratified archaeological sequences of Toé Cave, Kria Cave (Ayamaru Plateau, West Papua, Indonesia), Liang Lemdubu and Nabulei Lisa (Aru Islands, Arafura Sea, Indonesia) exposure to short-term high temperature heating events associated with campfires complicated interpretation of the extent of isoleucine epimerisation in *Casuarius* and megapode eggshells in terms of time and temperature. The extent of isoleucine epimerisation in *Alectura lathami* eggshells from Hay Cave (northeastern Queensland, Australia) enhanced the geochronological control for this site by clarifying the presence of temporal breaks in the sequence and providing an age estimate for a section of the sequence lacking age control. Late Holocene and Pleistocene populations of *Aepyornis* eggshells from the southern and southwestern coasts of Madagascar were readily distinguished by the extent of isoleucine epimerisation they exhibit.

Relatively high stable carbon and oxygen isotope ratios ($\partial^{13}C$ and $\partial^{18}O$ values) in Pleistocene *Casuarius* eggshells from the Aru Islands were consistent with a weaker monsoon during the Last Glacial Maximum. The absence of this trend in Pleistocene *Casuarius* eggshells from the Ayamaru Plateau suggested the latter site is less sensitive to fluctuations in monsoon effectiveness. Supported by isotope analyses of modern megapode eggshells, carbon fixed by C3 photosynthesis was identified at the base of the *Alectura* food chain from the $\partial^{13}C$ values of Hay Cave megapode eggshells. The interpretation of *Alectura* eggshell $\partial^{18}O$ values was complicated by their wide range, and this was most likely a product of the combined effects of evaporation on oxygen isotope ratios and the protracted breeding season. The lack of variation in the $\partial^{13}C$ and $\partial^{18}O$ values of *Aepyornis* eggshells was attributed to subsistence on C3 vegetation and the water of perennial ground water-fed ponds, whereas enriched nitrogen isotope ratios could be due to a number of factors including the infiltration of seawater into the littoral water table.

Overall, the research presented an opportunity to examine the strengths and weaknesses of information extrapolated from isoleucine epimerisation and isotope ratios in avian eggshells in novel taxonomic and geographical settings. The high temperature experiments further documented the taxonomic dependency of the rate of isoleucine epimerisation in avian eggshells and indicated that the temperature sensitivity of this reaction is

similar amongst eggshells. Although interpreting the extent of isoleucine epimerisation in eggshells from archaeological sites in terms of time and temperature was readily complicated by exposure to campfire heating events, the ability to demonstrate a close correlation with independent age control indicated that this problem is not ubiquitous in these contexts. The $\partial^{13}C$ values of eggs-hells broadly identified the vegetation that herbivorous birds consumed, and where the photosynthetic pathway of this vegetation was known, eggshell $\partial^{13}C$ values provided information on the $\partial^{13}C$ value of this biomass. The nitrogen isotope ratios of eggshells could be successfully integrated with existing know-ledge of ancient habitats, and eggshell $\partial^{18}O$ values were used to identify drinking water sources and trace climatically-significant changes in these reservoirs over time.

The Gulf of Carpentaria Palaeoenvironments: OSL Dating and Nannofossil evidence

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The Gulf of Carpentaria is a near equatorial region, a domain in which past environmental changes are not well understood, but in which much of the world's weather has its origin. Being situated adjacent to the Western Pacific Warm Pool, responsible for the largest transfer of heat and moisture between the surface and the atmosphere, the Gulf of Carpentaria is an epicontinental sea (maximum depth 70 m) bordered to the east by Torres Strait (12 m depth) and to the west by the deeper Arafura Sill (53 m depth), an area sensitive to the Asian monsoon and ENSO, which have a crucial importance on a worldwide scale. Furthermore, this region could be a key point to monitor the palaeocirculation between the Pacific and the Indian oceans that records the switching on and off of the global thermohaline circulation during glacial/ interglacial alternations. The Gulf is tectonically stable, therefore no corrections are necessary when interpreting the palaeo-sea level curve. Throughout the Late Quaternary, during times of sea-level low-stands, the gulf was separated from the open waters of the Indian and Pacific oceans, forming Lake Carpentaria with outlet channels to the Arafura Sea.

In 1997, six sediment cores were collected from the Gulf of Carpentaria using a giant piston-corer deployed from the Marion Dufresne, as part of the International MArine Global changEs Study (IMAGES). This study provides an interpretation of the palaeoenvironments in the Gulf of Carpentaria over the last 175 ka by means of OSL dating and analysis of abundance and distribution of coccolith assemblages within this series of sediment cores. The usefulness of the OSL Dating technique on such sediment cores covering marine to lacustrine conditions has been demonstrated by establishing a time frame for the changing environments of the Gulf of Carpentaria since MIS 6.6. The shallowness of the Gulf of Carpentaria, as well as its restricted basin size, allow the use of Optically Stimulated Luminescence (OSL) to date the sediment. Indeed, these parameters mean that the quartz grains were bleached soon before deposition and thus that the event date is the real time of deposition. From the thirteen samples processed, twelve dates ranging from 7 ± 1 to 175 ± 13 ka, have been estimated over three cores from the Gulf of Carpentaria. These dates also allow the calculation of the sedimentation rate, which ranges from 4.3 cm ka^{-1} in the central area to 7.8 cm ka^{-1} on the western margin. These results are consistent with the modern sedimentation rate observed in the Gulf of Carpentaria. A clear reduction in the sedimentation rate starting about 90 –100 ka ago is noticed in the three cores, however this needs to be confirmed by further dating on other levels.

Coccolithophores are planktonic marine algae distributed from the open ocean to nearshore littoral and lagoonal environments. They secrete minute calcified plates, coccoliths, which are a major component of pelagic carbonates. Coccolith assemblages preserved in marine sediments are excellent proxies of palaeoceanographic conditions. The lack of coccoliths could be either due to bad preservation conditions or to a freshwater environment. In the Gulf of Carpentaria, coccolith assemblages confirm at least two non-marine/marine cycles, during the past 175 ka, as well as some short marine intervals, as minor incursions of seawater during a non-marine sequence.

These collated results are presented on a series of maps illustrating the discrete closure and breach sequences of the Arafura Sill and Torres Strait as related to Quaternary sea level fluctuations, and the corresponding alternations between the Gulf of Carpentaria and Lake Carpentaria. When viewed together, the compilation and interpretation of these data enables the development of a detailed spatial and temporal understanding of the palaeoenvironmental history of the Gulf of Carpentaria since MIS 6.6 (ca. 175 ka). From the sedimentary record of the Gulf evidence of dry and wetter episodes are observed and interpreted as intensification of the monsoon and cyclonic activity. These may be linked to ENSO events and global oceanic and atmospheric processes.

Developing methods for identifying cryptic tephra in peat cores from the Waikato region, North Island, New Zealand

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Peat cores collected from two ombrogenous bogs in the Waikato region of the North Island of New Zealand are subjected to a range of analytical methods that are capable of detecting the cryptic ('hidden') tephra content in the cores. The peat sections of interest are bracketed by the Taupo (~1750 cal BP) and the Tuhua tephras (~7000 cal BP) in two cores from Kopouatai Bog (37°26'S, 175°34'E) and by the Taupo and the Mamaku tephras (~8000 cal BP) in one core from Moanatuatua Bog (37°58'S, 175°72'E). Non-destructive methods used include photo-spectrometry and magnetic susceptibility. Results from Total Organic Carbon (TOC) analyses were made available from an ongoing study (Zoe Hazell, PhD at University of Plymouth, completed 2004). Concentrations of tephra shards are determined by 'ashing' the peat and by counting under a light microscope tephra shards mounted onto microslides. More detailed counts in one core are used to assess the vertical spread of the cryptic component of the visible Taupo Tephra and to determine its sedimentological characteristics. Images from Scanning Electron Microscopy and low-power light microscopy reveal characteristic micro-morphological features of selected tephra shards.

An appraisal of the various detection methodologies indicates that problems are associated with all. Magnetic susceptibility measured by the Bartington MS2 only detects tephra high in ferro-magnesium content and does not yield satisfactory results for tephras embedded in peat. Reflectance measurements using a Perkin Elmer Luminescence Spectrometer give reasonable results for high-quality (undisturbed and smooth) cores, but peaks may also be produced by material other than tephra. TOC analysis is best capable of detecting cryptic tephra, but the method is partially destructive and time-consuming.

The tephra attenuation study shows that fine shards of the Taupo Tephra were detected at 30 cm below and at 11 cm above the visible component of the layer. It is likely that bioturbation by micro-organisms, transport along root canals and re-deposition by wind are processes that may redistribute cryptic tephra shards through the peat. Micromorphological analyses of the cryptic tephra shards are useful to characterise potentially distinguishing features of cryptic tephra (e.g., rhyolitic *vs*. andesitic appearance, chemical weathering, etc.). These characteristics are used in combination with radiocarbon ages and chronostratigraphy of visible tephras to link discrete cryptic tephra horizons to possible eruptive events, but additional geochemical analyses are necessary to 'fingerprint' the tephras more conclusively. It is concluded that detection of cryptic tephra holds promising potential to enhance the region's tephrostratigraphic framework.

Modern and Recent seafloor environments (sedimentary, foraminiferal & ostracode) of the Pitt Water Estuary, south-east Tasmania

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The Pitt Water Estuary is a shallow, barrier estuary, of typically normal marine salinity, which has been subject to considerable anthropogenic modification since the onset of European settlement in the area.

Modern seafloor environments were described using the distribution of sedimentary facies and foraminiferal and ostracod assemblages, examined from surficial sediment samples. Ten sedimentary facies were identified by grouping sediment samples using particle-size distribution data and lithic sand content. Faunal assemblages were identified by cluster analysis, with twelve sample, and eight species associations defined by foraminifera, and eight sample, and six species associations defined by Ostra-coda.

The distribution of sedimentary facies varies, firstly, with the upstream change in relative current energy (tidal versus fluvial) as reflected by the relative proportion of quartzose to lithic sand in sediment; and, secondly, with the water depth variation in current strength, as reflected by the sand grain size and mud content. The distribution and composition of foraminiferal and ostracod assemblages is determined mainly by average salinity and pH. The position of species along the axis of the estuary correlates with the altered salinity profile which occurs during floods, with tolerance to lowered salinity greater further upstream. Low pH conditions are widely distributed (due to the anoxia of stagnant, nutrient-enriched waters), causing calcareous test dissolution which, in some areas, totally excludes calcareous foraminifera and ostracods. Illumination is also important in controlling ostracod distribution, being lowest in widespread turbid waters. Additional factors controlling foraminiferal and ostracod distribution include: substrate mobility, nutrients, seagrass distribution, tidal exposure, and tolerance to varying temperature.

Recent seafloor environments were described using the distribution of sediments, foraminifera and ostracods in short cores and previous spatial surveys. They have changed considerably since the late 19th century, mainly as a result of human activities which continue to affect the estuary.

During periods of increased agricultural activity (1920s–1940s; 1960s–present), greater land clearance, cultivation and fertiliser usage within the catchment area, lead to increased sediment and nutrient loading of fluvial waters entering the estuary. This lead to increased sedimentation, mud accumulation, turbidity, and lowered dissolved oxygen and pH within the estuary, causing the demise of dense clam and oyster beds, reduced distribution of ostracods and calcareous foraminifera, increased distribution of agglutinated foraminifera, and increased faunal abundance within nutrient-enriched sediments. Dam construction and irrigation activities during the 20th century, reduced rainfall over the last thirty years, and causeway construction during the 1870's, have all contributed to increased water stagnation, reduced flushing, and more upstream penetration of the estuary by marine waters.

Palynological evidence of vegetation dynamics in relatively undisturbed and disturbed sites in New Zealand

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New Zealand forest has been affected by both natural and anthropogenic disturbances. Protecting and restoring indigenous forest is one of the focal issues in conservation of New Zealand, and understanding vegetation dynamics is a key part of management strategies. The longevity of most New Zealand trees impedes short-term vegetation dynamics studies. Instead fossil pollen records provide one of the most valuable sources of long term data to trace vegetation development. In this study, pollen records are used as proxies of vegetation population to test the roles of long-term climate change and transient environmental disturbances in vegetation dynamics. Two sediment cores, from Sponge Swamp, Haast, and Tiniroto Lakes, Gisborne, were collected as representatives of undisturbed and disturbed sites, the former being used as a reference site to separate out the effects of climate and evaluate the impact of disturbance on the vegetation.

Pollen data were inspected using Tilia, and zones defined. Principal component analysis (PCA) was performed on pollen data to summarise the change in species composition over time, and the sample scores of the first PCA axis were exploited as an index of vegetation dynamics for further comparison. Redundancy analysis (RDA) is also applied to help interpretation of the vegetation change with respect to environmental factors.

The result of this study indicates that the vegetation development in both sites is characterized by non-equilibrium dynamics, in which vegetation composition is changing continually through time. In Sponge Swamp, this change is steady and

consistent over the whole time span, with a consistent decline of *Ascarina lucida* and a progressive increase of cold tolerant or moisture-stressed taxa, like *Gleichenia* and *Lycopodium australianum*. Subsequently there is a partial replacement of swamp forest taxa such as *Dacrycarpus dacrydioides* and tree ferns by *Prumnopitys taxifolia*, and further expansion of *Nothofagus* and *Phyllocladus* is distinguished. A climate gradient, from mild and wet to cooler and/or drier is suggested fro the pollen evidence, and appears the driving force for the vegetation dynamics at that undisturbed site. At Tiniroto, however, the vegetation development is divided into two stages. Before c. 2300 yr BP, the vegetation change is steady and consistent which is comparable to that from Sponge Swamp. A forest invasion, a process of gradually replacing open land and light-adapted taxa, such as *Dodonaea viscosa*, *Coprosma*, *Pseudopanax*, *Schefflera digitata*, *Pteridium*, *Hebe* and members of the family Fabaceae and Asteraceae, by increasing proportions of forest taxa, characterise this change. Climate amelioration with increased rainfall is responsible. After c. 2300 yr BP, this trend was frequently punctuated by disturbances, in which sudden changes of vegetation occur, generating substantial fluctuations about the trend.

From RDA, sample age explains more than 20% of the variance of species data at both sites. The long-term directional climate change derived from pollen evidence of Sponge Swamp and at least partly at the Tiniroto site, may be represented by the explanatory variable age. At Tiniroto, additional variance is also explained by the explanatory variables charcoal and pollen taxonomic richness, suggesting the impact of disturbance on vegetation dynamics. The impact of disturbance on vegetation dynamics becomes clearer after the climate gradient is removed. Autocorrelation analysis on detrended sample scores of the first PCA axis suggests further differences between the two sites, in response to local disturbances. There is little dependence of the present state of vegetation composition on its past state in the Sponge Swamp site; instead, the vegetation composition is affected by various "random" events, implying small disturbances such as floods, or landslides caused by earthquakes etc. At Tiniroto, the change of vegetation composition is more "successional", and the present state of vegetation depends only on the immediate past state, due to the impact of catastrophic disturbance.

Despite the Tiniroto site having been subjected to a long history of disturbance, the climate gradient, which is distinct at the earlier stage, becomes less identifiable and partially masked by outbreaks of disturbances only since c. 2300 yr BP. This implies that the relative role of disturbance on vegetation dynamics with respect to climate is depended on different types or different levels of disturbances and different responses by the vegetation.

Short-term vegetation responses to different types of disturbance were examine by fine resolution pollen analyses around five disturbance episodes, including the Taupo (1850±10 yr BP), Waimihia (3280 ±20 yr BP) and Whakatane (4830–20 yr BP) eruptions, and two charcoal peaks (c. 1100 yr BP and c. 2300 yr BP). Almost no vegetation change occurred relative to the eruption within the Whakatane and Waimihia episodes, except that a temporary rise of shrubs and ferns corresponded with intermittent occurrence of charcoal particles. Substantial vegetation change relative to disturbance was found within both the Taupo episode and the fire episode around c. 2300 yr BP, in which establishment of ensuing semi-open vegetation was encouraged for decades. The fire c. 2300 yr BP transformed part of the forest into fernland, while the Taupo eruption turned part of the shrubs and tree ferns into bracken field. although it is difficult to judge the effect of the fire around 1100 yr BP as the result was unreliable due to contamination, the vegetation at Tiniroto is suggested to be more vulnerable to fire than tephra.

Non-equilibrium dynamics are common in New Zealand forests, even at stable sites such as Sponge Swamp, due to climate change. Locally these non-equilibrium dynamics appear highly responsive to disturbances, especially at Tiniroto. Even disturbances at Tiniroto are dynamic and a change of disturbance regime is suggested around the later disturbance episodes. This change is possibly due to climate increasing the fire frequency, but an alternative explanation is the presence of humans earlier than currently accepted. Forest and forest ecological studies in New Zealand are very dynamic, and forest management needs to improve to incorporate these dynamics.

A Palaeolimnological Approach to Understanding Sediment and Nutrient Sources of Warren Reservoir, South Australia

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Warren Reservoir, Mount Lofty Ranges, South Australia (34° 45'32 S, 139° 02'47 E) receives transfers of water from the Murray River experiences regular cyanobacterial blooms, which are "dosed" with copper sulphate. A paleolimnological investigation was conducted on Warren Reservoir with the aim of better understanding how nutrient enrichment and sedimentation have impacted the system.

The investigation compared the geochemistry of a fossil sediment sequence raised from Warren Reservoir with the geochemistry of catchment and Murray River modern samples. Warren Reservoir sedimentation rates have been relatively constant since commissioning in 1916, with an annual accumulation rate of 1.3 +/- 0.2 cm. The geochemical sediment analysis eliminated the Mannum–Adelaide pipeline as a major source of sediment and revealed that the major source of Warren Reservoir sediment was two sub-catchments. Furthermore, it was shown that cleared grazing land provided more sediment than intensive land uses such as forestry.

The Reservoir's sediments contained very high concentrations of copper, which for many levels exceed national water quality guidelines. Historical records of SA Water copper dosing were compared with the copper concentration in the sediment sequence. This revealed such a strong correlation that the beginning of dosing in 1950 could be matched with increased concentration in the core and thus used as an independent verifier of sediment age, to strengthen an already reliable chronology.

Diatom analysis provided a Diatom Inferred – Total Phosphorus (DI-TP) record of water quality in Warren Reservoir. There was a dramatic increase in DI-TP around the time of initial Mannum-Adelaide pipeline pumping which eventually exceeded four times pre-Murray levels. The diatom taxa also show clear shifts from an initial aerophilous post-reservoir filling zone, to a low nutrient pre-Murray zone and finally a post-Murray high nutrient zone. It was estab-

lished that although the Mannum-Adelaide pipeline was not a major source of sediment, as is the case in other Mount Lofty Ranges streams, it appears to be the primary source of nutrient enrichment.

Intra-annual Variation in Ablation & Surface Velocity on the lower Fox Glacier, South Westland, NZ

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Intra-annual variations in ablation and surface velocity were investigated on the lower Fox Glacier, South Westland, New Zealand. Large variation between summer and winter ablation rates were recorded, with daily averages of 129 mm d^{-1} and 22 mm d^{-1} respectively. During summer, debris-cover significantly reduced ablation (50%), and ablation suppression increased as debris thickness increased. In winter, ablation suppression was not so apparent, but during heavy precipitation events, ablation under debris cover was half of that occurring on the clean ice surface. Variations in climate variables were found to account for over 90% of ablative variability during both summer and winter monitoring. Significant increases in ablation were found to occur with heavy precipitation events.

Surface velocity averaged 0.87 m d^{-1} during summer and 0.64 m d^{-1} in winter, a reduction of 26%, and if recent increases in ice thickness are taken into account, this deceleration increases to 32%. Reductions in velocity during winter are attributed to a decrease in water supply. During winter, precipitation events were found to increase velocity by up to 44%. The velocity response to precipitation events could be instantaneous, but on some occasions a time lag was present. This temporal variability is interpreted as either variation in the morphology of the glacial drainage system, affecting the efficiency of water transport to the base of the glacier, and/or to water storage. Both processes influence water pressures in the sub-glacial drainage system, which when increased, can enhance basal sliding.

Utilising data from this study, a response time for the Fox Glacier was estimated at around 9 years. This figure correlates well with previous end-of-summer-snowline surveys conducted by the National Institute of Water and Atmospheric Research (NIWA), and points towards the current (2005) advance being linked to gains in mass in the mid 1990s. Mass fluctuations of the glacier appear to correlate well to the global circulation pattern of the El Niño Southern Oscillation.

All the Small Things The Refinement of Foraminiferal Analysis to Determine Site Formation Processes in Archaeological Sediments

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Foraminifera are single cell protozoa that are ubiquitous in marine environments. The hard casings, or tests, of foraminifera are routinely studied in the earth sciences, particularly for palaeoenvironmental information. Foraminifera have been little studied by archaeologists, however, despite their potential to contribute to understandings of coastal site formation processes and localised palaeoenvironments.

In this study techniques and methods of foraminiferal analysis are developed and applied to the problem of distinguishing between natural and cultural marine shell deposits, using the Mort Creek Site Complex, central Queensland, as a case study. Results allow unambiguous demarcation of the natural and cultural deposits studied based on patterns of foraminiferal density. Natural deposits were found to have more than 1000 foraminifera per 100g of sediment, while cultural deposits exhibited less than 50 foraminifera per 100g of sediment. The range of taxa represented in the foraminiferal assemblage is consistent with a shallow water sub-tropical marine eco-system, indicating general environmental stability throughout the period of deposit formation. Findings are applied to re-evaluate previous models of site formation at the Mort Creek Site Complex.

Holocene sea-level change and the aminostratigraphy of wave-dominated barrier estuaries on the southeast coast of Australia

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The degree of aspartic acid racemisation measured in radiocarbon dated specimens of fossil molluscs collected from Holocene barrier estuaries on the southeast coast of Australia is evaluated in the context of results of laboratory-induced racemisation established in heating (simulated ageing) experiments. The general kinetic trend of aspartic acid racemisation, in both heating experiments, and at ambient temperatures during diagenesis in the fossil molluscs *Anadara trapezia* and *Notospisula trigonella* conforms to a model of apparent parabolic kinetics. Using the apparent parabolic kinetic model, numeric ages based on the degree of aspartic acid racemisation in fossil specimens of *A. trapezia* and *N. trigonella* have been determined. Aspartic acid D/L ratios in Holocene specimens of *A. trapezia* and *N. trigonella* range from 0.049±0.005 to 0.510±0.009, representing an age range from <50 yr to ca 8,000 yr. Accordingly, the Holocene amino- and chronostratigraphies of the wave-dominated barrier estuaries Lake Illawarra, St Georges Basin, Swan Lake and Burrill Lake have been established based on the extent of aspartic acid racemisation measured in 290 specimens of fossil molluscs. For fossil material beyond the time span of the radiocarbon dating method (ca >50 ka) and the calibration range of aspartic acid, relative ages have been determined based on the slower racemising acids alanine, valine, leucine and proline. The relative age determinations on older fossils indicate that Last Interglacial successions have been preserved at depth within the incised valleys on the southeast coast of Australia.

Aminostratigraphy, in conjunction with thermoluminescence dating, additional radiocarbon ages, and the litho- and biostratigraphic analysis of 141 vibracores, allowed the detailed assessment of the geomorphological evolution of wave-dominated barrier estuaries that formed in both broad, and narrow, incised valleys on the southeast coast of Australia. Results from the stratigraphic and geochronological analysis show that the estuaries investigated in this thesis have an evolutionary pathway that is different to previous models of barrier estuary evolution. In contrast to the earlier models of barrier estuary evolution, this thesis places a greater emphasis on the influence of the antecedent Late Pleistocene landsurface on the geomorphological evolution of barrier estuaries on the southeast coast of Australia. The Late Pleistocene sediments are represented by dense, mottled estuarine

clays and/or by remnant barrier systems comprising medium-grained quartz sand with a clay matrix. The Late Pleistocene sediments preserved within the incised bedrock valleys represent sedimentary successions deposited during previous high-stands in sea-level that have undergone minor diagenetic alteration during subsequent sea-level lowstands. Therefore, the Late Pleistocene sediments now represent low-stand weathering profiles and provided the substrate over which Holocene sedimentary successions have been deposited. In particular, the preservation of remnant Last Interglacial barrier systems are found underlying the Holocene barrier systems and provide a core over which Holocene barrier sediments have accumulated.

Results from this study have also shown that Holocene transgressive sands are more extensive than previously anticipated and form a basal, near basin-wide shell-rich deposit that extends almost up to present sea-level. The transgressive sandsheet facies lies unconformably over the Late Pleistocene antecedent landsurface and was deposited during the most recent post-glacial marine transgression (PMT) when rising sea-levels breached Last Interglacial remnant barriers and inundated shallow incised valleys causing more open marine conditions to persist between 8,000 and ca 5,500 years ago. This contrasts with established models for barrier estuary evolution on the southeast coast of Australia where Holocene PMT sandsheets were restricted to the mouths of incised valleys and back-barrier central basin muds lie directly over the antecedent Pleistocene landsurface.

This study also presents a database of 121 previously published radiocarbon ages obtained from fossil molluscs, organic material and fixed biological indicators from back-barrier sedimentary successions and the marginal marine environment on the southeast coast of Australia that have been used to constrain Holocene sea-level fluctuations. The database has been limited to fossil materials that have an accurate description of facies association and stratigraphic relationship to present mean sea-level (PMSL). An assessment of the uncertainty terms associated with the various proxy sea-level indicators is made and radiocarbon ages are calibrated to sidereal years. Additional radiocarbon ages and aspartic acid racemisation-derived ages obtained on fossils preserved in the Holocene PMT sandsheets deposited in shallow incised valleys are presented in this thesis. A synthesis of the previously published radiocarbon ages and new data presented in this thesis has permitted a revised Holocene sea-level curve for the southeast coast of Australia to be delineated. Results show that rising sea levels during the most recent PMT attained an elevation of around -10 m by 10,000 cal yr BP and continued to rise to *ca* -5 m by 8,500 cal yr BP. Between 8,300 and 8,000 cal yr BP sea-level had risen to at least 3 m below PMSL and inundated shallow incised valleys, resulting in the deposition of shell-rich transgressive sandsheets. The most recent PMT sea-levels attained present levels around 7,700 cal yr BP, slightly earlier than a previously proposed culmination of *ca* 7,000 cal yr BP. Results indicate that sea-level continued to rise to between 1 and 1.5 m above PMSL by 7,400 cal yr BP during the culmination of the most recent PMT and was followed by a sea-level highstand that lasted to some time between 3,000 and 2,000 years ago. This was followed by a relatively slow and smooth regression of sea-level from ca +1.5 m to present levels. A series of minor negative and positive oscillations in relative sea-level associated with variations in ocean topography and/or climate change during the mid to late Holocene appear to be superimposed over the Holocene sea-level highstand and subsequent smooth sea-level regression.

This study highlights the potential of aspartic acid racemisation as an important supplement for dating of fossils preserved in Holocene marginal marine deposits. This thesis also represents the most rigorous application of the aspartic acid racemisation dating method to the investigation of Holocene sedimentary infill of incised valley systems, and sea-level change during the most recent PMT. The evolutionary models of barrier estuary evolution developed in this thesis show that both the antecedent Late Pleistocene substrate and fluctuating Holocene sea levels have had a greater influence on the geomorphological evolution of barrier estuaries than previously anticipated. These revised models of estuary evolution can be applied to other shallow incised valley systems on tectonically stable, wave- dominated coastlines, and provide a template for future studies in wave-dominated barrier estuaries on the southeast coast of Australia.

Depositional characteristics of recent and late Holocene overwash sandsheets in coastal embayments from southeast Australia

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Sedimentary evidence for large-scale washover deposition along the Australian southeast coast is found as sandsheets in estuaries and anomalous boulder accumulations on rocky ramps and headlands. Large imbricated allochtonous boulders found elevated up to 33m above present sea-level indicate high energy deposition on sheltered rock ramps and coastal headlands and attest to very high wave energy in the past. Analysis of the sedimentary structures within the boulders can in places be related to ramp lithology and identify significant transport distances where the original position of the boulder is identified. The most striking boulder deposits are found in the ambient location of a large bay and have been transported more than 30 m horizontally along a boulder ramp and elevated to a height of more than 7 m above present sea-level. Although this evidence is striking, it is impossible to identify if the boulders were moved in one movement or have been moved by several events over time.

This study presents sedimentological evidence for a tsunami event(s) found in the upper fill of several embayments along the coast. Laterally extensive marine sandsheets are identified in back-barrier lagoons and elevated shell-rich sands are found on the margin of a large drowned river valley. These deposits exist up to 3km from the influence of modern coastal processes. The back-barrier sandsheets contrast with the finer confining sediments of the coastal lagoon and barrier estuary.

Interpretation of the depositional history of the deposits is conducted with reference to a global review of overwash deposition and a modern analog from the southeast Australian coast. In the absence of any geological evidence for known tsunami events on this coast, the deposits are compared to two modern sandsheets that were deposited during two large storms in 2001. This study therefore allows direct comparison of the deposits of unknown source to the storm deposited sediments found Abrahams Bosom Beach.

A large sandsheet is identified at Killalea Lagoon is composed of mixed marine sediment dominated by dune and beach sand but also containing platy heavy mineral assemblages indicative of nearshore to inner shelf sediments. This marine sediment is mixed with clumps of coastal vegetation and rip-up clasts of soil and lagoonal muds and clays.

The marginal drowned river valley material in a small embayment at Batemans Bay includes a coarse shell-unit containing large, often articulated, bivalve shells and oysters, along with cobbles of mixed lithology in a matrix of marine sand suggesting deposition of predominantly seaward tidal channel material.

The advantage of the sandy deposits lies in the analysis of their internal sedimentology and the presence of datable peat and shelly sands that confine the sand sheets and coarse shell-rich deposit respectively. The internal sedimentology of the deposit yields little structure and sediments consist of a series of massive, laminated and graded beds that often incorporate organic debris. These deposits contrast with storm washover deposits investigated at Abrahams Bosom Beach from the same coast that consist of thin graded beds of beach face and dune sediment only. These latter beds are a few centimeters thick and can be traced throughout the deposit. The storm deposits are the result of numerous wave-generated landward pulses while the larger, more chaotic deposit is the result of several very large pulses capable of eroding and transporting shelf, nearshore, dune and terrestrial sediments landward followed by partial reworking by back flow. These characteristics are indicative of the chaotic reworking of such deposits by short-lived high-energy events attributed to tsunami.

Dating of the Batemans Bay sequence was problematic and the shell-rich unit can only be confined to an age of around 1000 yrs At Killalea Lagoon optically stimulated luminescence (OSL) dating of quartz sediments from the sandsheets supplemented dating of the confining peat deposits by AMS radiocarbon.. Although affected by groundwater contamination, dates from the Killalea Lagoon site suggest that the depositional event is attributed to a large-scale inundation event between 200 and 800 years ago adding to a considerable bank of published dates that cluster around this period. Possible tsunami sources include sediment slides off the continental slope of Australia or New Zealand, seismic events in New Zealand and the Macquarie Ridge and bollide impacts in the Tasman Sea or southwest Pacific.

The environmental reconstruction of the last glacial cycle at Redhead Lagoon in coastal, eastern Australia

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This study reconstructs the palaeoenvironmental history during the last full glacial cycle (approximately the last 75,000 years) at Redhead Lagoon, an enclosed lake basin located in coastal, eastern New South Wales, Australia. This has been achieved primarily through sedimentological, palaeoecological and mineral magnetic analyses of long cores. The sequence adds to the limited number of long-term records in Australia and from this region in particular.

The chronology of the sediment record is established through AMS radiocarbon and Optically Stimulated Luminescence (OSL) dating. More than 30 AMS radiocarbon ages, using a variety of pre-treatment methods, have been obtained for three cores, which makes this one of the most comprehensively dated lake sediment sequences thus far in Australia.

During the initial stages of the last glacial period the site was dominated by a mobile dune system with no permanent water, supporting only semi-arid vegetation communities. The dune sand was part of a sequence of cliff-top dunes located on nearby Dudley Bluff emplaced by a process of 'sand ramping' during an earlier Pleistocene phase of lower sea level.

Pollen analysis indicates that the sequence of vegetation changes seen at Redhead Lagoon broadly compares with the cyclical pattern of climatically induced changes seen in many other pollen records in southeastern Australia. Alternating open herbaceous and woodland/ forest communities correspond with glacial and interglacial periods respectively. Superimposed on this pattern is a change towards a more open understorey vegetation assemblage, i.e. increasing values of Poaceae relative to Asteraceae (particularly type B) over the last 35,000 years.

A sharp increase in the incidence of Casuarinaceae from the height of the last glacial and its subsequent decline relative to *Eucalyptus* in the latter stages of the Holocene is evident. While reduced moisture availability may have initially facilitated the expansion of Casuarinaceae, the restriction of Casuarinaceae during earlier arid periods indicates that another factor appears to have been in operation. An examination of changing Chenopodiaceae/Casuarinaceae ratios, an indicator of salt-tolerance, shows that soil salinity may have been a significant contributor to the incidence of Casuarinaceae at Redhead Lagoon.

The driest period during the last glacial cycle occurred during MIS 2. A hiatus in one core from c. 28,000 to 12,000 BP may have been caused by the erosion of sediments during the LGM and late glacial period. However, deposits dating from this period are preserved in a second core. This core indicates the presence of a Casuarinaceae-dominated open sclerophyll woodland in association with grassland and low water balances during the height of the last glacial period.

The Holocene marks the start of a period of climatic amelioration. It is characterised by highly organic sediment deposition, an increase in pollen taxa diversity and the disappearance of several colder and/or drier taxa indicators (e.g. Asteraceae type B). The highest water balances in the sequence are attained during the early to mid-Holocene. This is suggested by the development of wet sclerophyll forest and the attainment of maximum values of taxa such as *Pomaderris* and *Melaleuca*. There is also a possible switch to a summer rainfall dominated climatic regime during this period.

Both microscopic and macroscopic charcoal counting methods have been employed in this study. Importantly, this has allowed the quantitative assessment of the macroscopic charcoal method over a longer time period than previously documented in Australian records. An evaluation of the two procedures reveals several notable differences. In particular, the macroscopic charcoal method records several more local fire events unable to be distinguished by the microscopic charcoal technique.

The relative importance of climatic and human influences on environmental change has been assessed. The majority

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Thesis Abstracts CONTINUED

of changes in the vegetation and charcoal records correlate with periods of significant climatic fluctuation. From around 35,000 years ago the vegetation became more open and ceased to support frequent or intense fires, resulting in a dramatic reduction in charcoal concentrations. This change may correspond with the start of a period of increased aridity that has been suggested from geomorphic evidence from southwestern New South Wales and increased ENSO variability. The small size of the Redhead Lagoon catchment, the close proximity of other larger and probably more attractive sites for humans, along with the limited population and nomadic lifestyle of the indigenous Aborigines, were probably major factors contributing to the relatively limited impact. In addition, the close proximity of the site to the coastline would likely have meant that fishing was an important activity and the open woodland found on this sandstone catchment is unlikely to have furnished many useful plant foods. Therefore, there may have been little advantage for humans in a location such as Redhead lagoon in manipulating the vegetation using fire.

During the mid-Holocene, however, there is evidence of increases in disturbed ground taxa and the 'fire adapted' genus *Eucalyptus*, along with increased charcoal fragments. In addition, there is a significant increase in the aquatic wetland plant *Typha*, which was extensively used by the Aborigines. In the absence of climatic stress the combination of these increases in various vegetation types and charcoal concentrations suggest that anthropogenic burning may have caused landscape change from this time.

There have been significant environmental changes since permanent European settlement began in the catchment. These include the introduction of several exotic vegetation types and significant increases in sediment accumulation rates, charcoal particles and possibly nutrient levels. In addition, there has been a decline in the incidence of several tree and rainforest taxa, which may reflect land clearing practices and the increasing fragmentation of forest communities after the arrival of European settlers. Changes in land use and human activity have had far more impact on the catchment than climatic and other natural fluctuations during this most recent period.

XVII INQUA Congress, Cairns 2007 Preparations are underway for the XVII INQUA congress in 2007 which will be held in Cairns, Australia from 28 July to the 3 August. The Australasian Quaternary Association is sponsoring the meeting. An initial information page has been set up at *www.aqua.org.au/AQUA/INQUA2007.html*

Please address all general enquires to *INQUA2007@aqua.org.au*

Controls of the ITCZ Position in Past Climates: Observations and Models (PP02) at the 2006 Joint Assembly of the American Geophysical Union, takes place in Baltimore, Maryland from 23–26 May 2006. The deadline for electronic submission of abstracts is 1 March 2006: *www.agu.org/meetings/ja06/*

Session conveners:
Tony Broccoli *broccoli@envsci.rutgers.edu* or
John Chiang *jchiang@atmos.berkeley.edu*

International Field Meeting on Sub-aerially exposed continental shelves since the Middle Pleistocene climatic transition. August 14–19, 2006 Exmouth and Ningaloo Reef, Western Australia. Department of Applied Geology, Curtin University, Perth, Australia. Sponsored by International Union for Quaternary Research (INQUA), PAGES, International Geosphere-Biosphere Programme (IGBP), Department of Applied Geology, Curtin University, Gascoyne Development Commission.

The project is aimed at the study of terrestrial deposits in sub-aerially exposed continental shelves since the Middle Pleistocene climatic transition (MIS 13). An important focus is the role of sub-aerially exposed continental shelves in carbon storage and the likely contribution of greenhouse gases into the atmosphere. Abstracts on all aspects of continental shelf sciences are welcomed for oral/poster presentations.

Convenor **Associate Prof Lindsay Collins**
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4th International Limnogeology Congress
Barcelona, 11–14 July 2007 *www.ilic2007.com*

CAVEPS 2007 11th Conference on Vertebrate Evolution, Palaeontology and Systematics
9 April – 12 April, 2007, Museum Victoria,
Melbourne Australia.

Conference convenors:
John Long (accommodation, dinner, venue)
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Australian Earth Science Convention
Melbourne 2–6 July 2006 *www.earth2006.org.au*

American Quaternary Association
Biennial Meeting, Bozeman, 17–20 August 2006
Ocean/Atmosphere Interactions and Continental Consequences: Environmental Forecasting from the Quaternary Sciences
http://bsi2.msu.montana.edu/amqua/meeting

10th International Paleolimnology Symposium
Duluth, Minnesota, USA, 25–29 June 2006
www.geo.umn.edu/paleolim10/
Abstract submissions will close 1 April 2006.

Conference co-chair:
Emi Ito: *eito@umn.edu*
Limnological Research Center, and
Department of Geology and Geophysics
University of Minnesota

HOLIVAR2006: Natural Climate Variability and Global Warming Environmental Change Research Centre (ECRC), University College London, 12–15 June 2006
Abstract submissions will close 1 April 2006.

www.holivar2006.org
www.holivar2006.org/registration.php

Quaternary AUSTRALASIA

Quaternary Australasia publishes news, commentary, notices of upcoming events, travel, conference and research reports, post-graduate thesis abstracts and peer-reviewed research papers of interest to the Australasian Quaternary research community.

Cartoons, sardonic memoirs, images of mystery fossils and amusing occupational health and safety breaches also welcome. Non-refereed material for QA 24 (1) should reach the editor by 1 June, 2006. Please ensure that citations are formatted to conform to *QA* style.

The Australasian Quaternary Association (AQUA) is an informal group of people interested in the manifold phenomena of the Quaternary... Sub-Era/Sub-Erathem. It seeks to encourage research by younger workers in particular, to promote scientific comm-unication 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.

The annual subscription is AUD$35, or AUD$25 for students, unemployed or retired persons. To apply for membership, please contact Janelle Stevenson (address at right). Members joining after September gain membership for the following year. Existing members will be sent a reminder in December.

ABOVE Vicuña above 4000 m. The wild camelids are recovering from the endangered species list in Parque Nacional Lauca in the altiplano, close to the Bolivian border. See Pauline English's report on the Southern Deserts conference, p. 19. Photo: P. English.