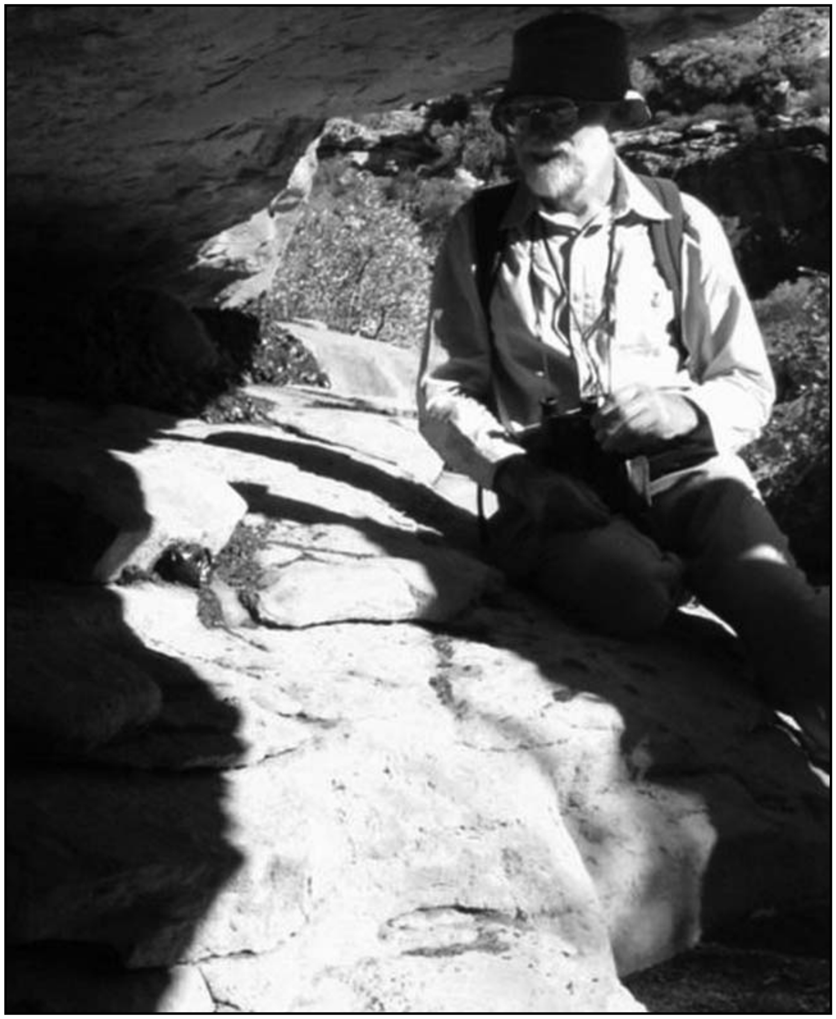
QUATERNARY AUSTRALASIA



Quaternary, quo vadis?
Proposed Neogenisation of the Quaternary, and Quaternarists' response

VOLUME 22 NO 1

JUNE 2004

CONTENTS

Cover photo

From the IV Southern Connections Conference, Cape Town, South Africa, January 2004. John Flux (Ecological Research Associates, New Zealand) examines a Hyrax midden at Traveller's Rest Farm, Cederberg region. These middens — the largest middens Stuart Pearson had ever seen — form important palaeoecological archives. Photo courtesy L. Gayler and S. Pearson.

Back Cover

A hyrax near Capetown, image courtesy of L. Gayler and S. Pearson and San rock art, image courtesy of M. McKenzie

ISSN 0811-0433

EDITORIAL

This issue of *Quaternary Australasia* includes discussion of an important challenge facing Quaternarists. The International Commission on Stratigraphy (ICS) has indicated its intention to eliminate the Quaternary, which has long lacked formal chronostratigraphic recognition, from the new Geological Time Scale by subsuming the past ~2 Myr within the Neogene. No doubt this is motivated in large part by a desire to rid stratigraphy of the last relics of Giovanni Arduino's 18th C. legacy of Primary-Secondary-Tertiary-Quaternary, since similarly the Tertiary will — probably with few objections? — be formally succeeded by the Palaeogene and Neogene. However, the need for this change is evidently not appreciated by many Quaternarists who, as a group, do not all think of their research as geological, let alone stratigraphic, and who, with very few exceptions, emphasise the many distinctive features both of the Quaternary and of our understanding of this most recent Period, that justify its special recognition and treatment. Brad Pillans, as president of the INQUA Stratigraphy & Chronology Commission, has offered for comment a counter proposal to the ICS (see page 8) through which it is hoped some formal status for the Quaternary can be retained; he then summarises, as well as reproducing verbatim, a range of responses that had been received as we went to press. Finally, a New Zealand perspective, viewed primarily through the lens of the incomparable Wanganui Basin, is offered by Naish, Beu and Alloway.

The Pillans INQUA proposal represents a compromise which retains the concept of the Quaternary at reduced status while extending the Neogene to the present. However, beyond this, a curious, innovative feature of the Pillans proposal which may prove to be its principal strength is that it attributes 'ownership' of the 2.6–1.8 Ma Gelasian Stage both to the Pliocene Series/Epoch (as is traditional) *and* to a novel Quaternary Subsystem/ Subperiod extending back to 2.6 Ma. Essentially this resolves the lingering ambiguity (at least from many Quaternarists' perspective) of Vai's (1997, *Quaternary International* 40:11–22) characterisation of the Gelasian as the 'glacial late Pliocene' by formally bestowing upon it 'dual nationality' status. That is, the Gelasian — the focus of late 1990s debate over the definition of the Pliocene-Pleistocene boundary — would simultaneously remain within the Pliocene and form a basal Stage within an expanded Quaternary. It is hoped that this may defuse persistent dissatisfaction in the Quaternary community over the location of the Pliocene-Pleistocene boundary, since the lower boundary of the Pleistocene would no longer correspond to the lower boundary of the Quaternary, hence would be of diminished (perhaps trivial) significance. We look forward to hearing whether the ICS accepts the Pillans INQUA proposal. While its complete rejection at the ICS might imply the need to rename (if facetiously) numerous 'Quaternary' organisations and entities such as this magazine (*Latest Neogene Australasia*?), its more probable success has already been anticipated by New Zealand's newly re-christened 'Friends of the Quaternary' (see the Wanganui field trip in Forthcoming events and meetings, p.39).

Also in this issue, Keith Bennett considers the intriguing links between European and Australasian bird faunas at seasonal to evolutionary scales, and the difficulties of understanding how these are linked with Milankovitch-scale climate changes; I review a recent special issue of *Philosophical Transactions of the Royal Society* based on a discussion meeting concerned with evolutionary impacts of the ice ages, which Keith was instrumental in organising. Also included are reports from the IV Southern Connections Conference, held in Cape Town during January 2004; a proposal by Peter Kershaw for a new INQUA palaeoclimate project on southern hemisphere land-ocean correlation; a report on Quaternary research being carried out at Monash University, and an abstract of Helen McGregor's recently completed thesis concerned with mid-Holocene ocean-atmosphere variability in the western Pacific warm pool based on coral reconstructions.

Kale Sniderman
Editor

PRESIDENT'S PEN

Writing the President's Pen always seems to come at the last minute for me. Having a tolerant and yet very efficient editor has been a great help here; with the new format of QA, and the burden* of copy editing being passed to the publishers, Pandanus Books at The Australian National University, my tardiness seems to have gone unnoticed. All this efficiency comes at a price, however, which is something our Association will have to address through a small rise in membership fees, to be voted on at the next AGM in Tasmania this year. At a recent meeting of executive and assorted AQUA members at the ANZGG in Mt Buffalo, Victoria, it was thought that a rise of around $5 in membership fees would not be too much. Given that our annual costs have risen by about $1,500 and our membership is approaching 300, I hope this will receive your support at the meeting in Tasmania.

Another reason for increasing our annual membership fees is the need to maintain our support of postgraduate students through the annual Postgraduate Travel Prize. This year there have been an unusually large number of applications from New Zealand (15)and almost every Australian state (with only West Australia and Queensland unrepresented), which bodes well for the future of Quaternary studies in the region. The recipient of the prize this year was Karen Carthew of the Department of Physical Geography at Macquarie University in Sydney. Karen will be attending the International Geomorphology Conference in Glasgow and will present data on the topic, 'An Environmental Model of Fluvial Tufas of the Seasonally Wet Tropics, Northern Australia'. All applications were of a high standard, so it is unfortunate that more of them could not be supported in some way. Perhaps further rises in membership fees in the future will help to facilitate this.

The biennial meeting in Cradle Mountain, Tasmania, in December of this year is shaping up to be a great event. Some great field trips are planned and it will be an excellent opportunity to explore Tasmania (before the school holiday rush). The meeting will hopefully bring together a wide spectrum of the Australasian Quaternary community, with palaeo-oceanographers and Antarctic scientists being invited to attend. The first presentation of talks from the Australasian INTIMATE program (INTegration of Ice core, MArine and TErrestrial records of the Last Termination) or, as it is now known, 'The Australasian INTIMATE project: towards an Event Stratigraphy for the Last Glacial Maximum and the Last Termination in Australasia' will also occur during this meeting. This will also be an opportunity to hear more about a new project, initiated by Peter Kershaw in his capacity as Secretary of the new INQUA Commission on Palaeoclimate, titled 'Land-Ocean Correlation of Long Records from the Southern Hemisphere at Orbital and Sub-Orbital Scales' (LOCLRSHOSOS?). This will also be the last AQUA meeting in Australia before the INQUA conference in 2007, so I hope that everyone will make an effort to attend. All the information you need is now on the web page.

Finally, with the budget having just been announced, how have our members fared? A few salient points from the FASTS summaries are worth noting:

- Total government expenditure on R&D in 2004–05 is estimated at $5342m, compared to the estimated actual of $5214.2m in 2003–04. If we use Treasury's own assumptions of 3.5% GDP growth and inflation of 1.75%, this means an increase in real terms of $91m and a cut against percentage of GDP of $149.1m.
- The Research Training Scheme increased from $585m to $587m — a cut in real terms.
- CSIRO received a $30m increase for the flagships program as part of the $300m increase over 7 years, announced last week. It also reverts to triennial funding agreements, as do the other PFRAs.
- The ARC appropriation increases from $413.9m to $482.4m as per the Backing Australia's Ability commitments of 2001.

Simon Haberle

*Editor's note: only some of the burden has been passed to the efficient Pandanus team…

GUEST EDITORIAL

Out of Australasia?

K.D. Bennett

Department of Earth Sciences, Uppsala University
keith.bennett@geo.uu.se

I write this in late April in Uppland, central Sweden. It is an interesting time of year here: the transition from winter to summer. An especially noticeable aspect of the changing season is the flood of birds into breeding habitats from their winter quarters somewhere to the south. The resulting change in bird numbers is enormous, as is the overall change in diversity. The three most common breeding birds in Uppland — chaffinch *Fringilla coelebs*, willow warbler *Phylloscopus trochilus* and robin *Erithacus rubecula* — are all migrants. If I work hard, I might find 70 species in the region during February, and more than 200 species during May. Some of the distances covered by these birds are remarkable, many of them migrating to and from southern Africa, for example. The Swedish long-distance record was recently set by an arctic tern *Sterna paradisaea*, ringed in June 2003 as a nestling in northern Sweden, and found dead on Stewart Island, New Zealand, in December: a straightline distance of 17,500km, but 25,000km by the most likely route (round South Africa).

We'll come back to these migrants shortly, but, firstly, something rather different. The question of the origin of species has long fascinated both geologists and biologists. Charles Darwin wrote a certain book that focused attention on mechanisms that are still contentious. But what about timescale? Darwin really had no idea. Some kind of basic biostratigraphy was in place during the nineteenth century, but timescales were more or less guesswork. The 'Ice Age' was a familiar concept, but its complexity was unknown. How the 'Ice Age' timescale related to timescales of other important phenomena, such as the origins of modern fauna and flora, for example, was unknown. Present day fauna and flora had an origin at some point in time, of course, but when? Are we talking about the Holocene, sometime earlier during the Quaternary, or even as far back as the Tertiary? Even if the answer varies between different groups of flora and fauna, it would be nice to have a handle on it.

Thinking about timescales of speciation since Darwin has been distinctly coy. In his classic work 'Systematics and the Origin of Species' (Mayr, 1942), Ernst Mayr avoids the topic almost completely. He speculates that subspeciation might take a few thousand years. But not all subspecies become full species. He also indicates that population mixing as a result of Quaternary climate change in higher latitudes would likely inhibit speciation. But he gives no indication of how old present species might be, although we can infer that he thought that their origins must be pre-Holocene at least. About 60 years later, he returned to the same theme, in co-operation with Jared Diamond (Mayr and Diamond, 2001), with a detailed analysis of the speciation processes leading to the modern bird fauna of Northern Melanesia. This analysis presents a 'movie' of five stages in the speciation process. Unfortunately, he provides no advice as to how fast the movie should be played. Many have assumed that the most recent glacial-interglacial cycles have been important in generating modern species (see references cited in Klicka and Zink, 1997).

Palaeoecologists have not been entirely silent in this matter. For the Quaternary, Russell Coope, in particular, has drawn attention to the lack of evidence for speciation among beetles (Coope, 1978), and Peter Kershaw has discussed the lack of extinction among plants (this being the other side of the coin) (Kershaw, 1984). Most Quaternary palaeoecologists implicitly assume a lack of evolution: we simply identify our fossils with modern species.

The advent and widespread use of molecular techniques for the analysis of DNA has, over the last decade, brought about a revolution in understanding timescales of speciation. We now have phylogenies for many groups of organisms at taxonomic scales that range from populations to phyla. Even better, these phylogenies can be placed on a crude timescale by means of the so-called ‘molecular clock’. This method is far from perfect (Rambaut and Bromham, 1998), but it does give results at a level that are usable and significant in relation to Quaternary timescales. Evidence from molecular phylogenies of songbirds (and many other groups) is pushing speciations back into the Tertiary (Zink et al., 2004). Our modern species have mostly been around for periods of up to 10 Myr, between 100 and 250 glacial-interglacial oscillations.

Apart from timescale, a major strength of the new molecular phylogenies lies in their ability to connect ancestries, which is something that it is very hard to do working solely from fossils. An early effort in this direction was made using DNA-DNA hybridization techniques to identify relationships among birds. The perching birds, or passerines, are divided into two groups — the suboscines and oscines — by the anatomy of their syrinx (the organ that produces song). Sibley and Ahlquist (1990) produced a controversial re-classification of all the world’s birds, in which they suggested that the oscine passerines consisted of two groups, one of which — Corvida, including Australasian birds-of-paradise as well as northern hemisphere shrikes and crows — originated in Australasia (where most still occur) but spread to Asia and, from here, radiated across the northern hemisphere. This conflicts with conventional thinking on the matter, in which Australasia is seen as a kind of passive dead-end, receiving but not providing. This thinking is evident in the pseudo-European names (New Zealand thrushes, Australian treecreepers, etc.) used for birds that have little morphological resemblance to their supposed European counterparts, and even less of a systematic relationship.

More recent work with molecular phylogenies, obtained by DNA sequencing, has substantially confirmed this ‘Out of Gondwana’ or even ‘Out of Australia’ view for a large part of the world’s bird fauna (Ericson et al., 2002). The suboscine and oscine passerines diverged in the late-Cretaceous and the oscines radiated out of Australia and into Eurasia, and thence into North America (either from the east or the west) and, finally, to South America, after plate movement merged the two American continents. The suboscines also radiated from Gondwana into South America and Africa/southern Asia. The New Zealand wrens *Acanthisitta* predate the oscine/suboscine split, and their molecular phylogeny is consistent with an origin at the time that the New Zealand landmass separated from the rest of Gondwana, about 85 Ma.

Passerine birds have radiated across the world to the extent that their Gondwanan origin is no longer visible in their modern biogeography. On the other hand, there are groups of birds all over the world that have radiated regionally, as part of the major radiation of birds. Some of these lesser radiations have probably included movement back into Australasia.

What does all this have to do with the Swedish spring and arctic terns? At some point in the next week or so, I shall visit the coast. I shall see arctic terns that have migrated from Australasian seas in the past few months. I will see and hear various passerines, all of which are probably the result of speciations in Europe, perhpas within the last 10 Myr, and which include descendants of lineages that radiated out of Australia perhaps 70 Myr ago. These passerines will mostly be migrants that have returned to central Sweden from various wintering grounds that range, depending upon species, from further south in Europe to the southern tip of Africa. A small group of species migrate between Scandinavia and southeast Asia. Scandinavia was completely glaciated during the last glaciation, and probably several (many?) times previously. All of these migrants must have shifted their migration ranges as climate has changed. At the Scandinavian end, this means change on timescales of every 100 kyr over the last 600 kyr, and every 40 kyr before then. The amplitude of these changes, particularly during the last 600 kyr, has been substantial, possibly the largest the world has seen during the current phase of ice ages. At the southern end, the situation is more complex. In low and mid-latitudes, dominance of timescales of precessional frequencies would be expected (20 kyr), but a wide-range of periodicities may occur, including some that are apparently non-Milankovitch (Kershaw et al., 2003). Species such as my arctic terns must be simultaneously adjusting to climate change at different temporal scales — sometimes in phase, sometimes not — in different parts of the world!

As Quaternary researchers, we are used to thinking about global climate change and the ways in which change is transmitted around the planet, by air or by water. Biodiversity, however, is a global phenomenon. Changes in one place have impacts elsewhere. Such changes operate at a variety of temporal scales, from initiation of new groups — such as the Australian oscine passerines that now dominate the world’s bird fauna — through northern hemisphere glaciations affecting distributions of arctic terns that spend the northern winter in the southern summer (and vice versa), down to the annual movement of billions of birds across the equator.

Australasia may not have the equivalent of a Swedish spring, but the connections between Australasian bird faunas and European faunas are surprisingly strong at both at an individual level as well as at the level of evolutionary relationships. Even more surprising is the degree of flexibility that appears to be present in the way that species respond to climate change on Milankovitch scales (whether strictly 'Milankovitch' in origin or not). As our understanding of global climate change at these scales deepens, our understanding of species response seems to become relatively weaker. We now have access to timescales and molecular phylogenies, both of which Darwin and his generation lacked. One of the most interesting questions for the next decade is going to be whether we can use these timescales and molecular phylogenies to start pinning down origins of species in time and space in such a way that we can test Darwin's hypothesis. Quaternary palaeoecologists should be playing a strong part in this work, as much of the action may be more visible within the last 2 Myr than in any other part of the fossil record. However, we might have to be prepared to discover that, while the phenomenon takes place on, or within, Milankovitch timescales, it is not particularly associated with the Quaternary.

References

Coope, G. R. 1978. Constancy of species versus inconstancy of Quaternary environments. In Mound, L.A. and Waloff, N. (eds), *Diversity of Insect Faunas*, 176–187. Blackwell, Oxford.

Ericson, P. G. P., Christidis, L., Cooper, A., Irestedt, M., Jackson, J., Johansson, U.S. and Norman, J.A. 2002. A Gondwanan origin of passerine birds supported by DNA sequences of the endemic New Zealand wrens. *Proceedings of the Royal Society of London Series B* 269: 235–241.

Kershaw, A. P. 1984. Late Cenozoic plant extinctions in Australia. In Martin, P.S. and Klein, R.G. (eds), *Quaternary Extinctions: a Prehistoric Revolution*, 691–707. University of Arizona Press, Tucson, AZ.

Kershaw, A. P., van der Kaars, S. and Moss, P. T. 2003. Late Quaternary Milankovitch-scale climatic change and variability and its impact on monsoonal Australasia. *Marine Geology* 201: 81–95.

Klicka, J. and Zink, R. M. 1997. The importance of recent ice ages in speciation: A failed paradigm. *Science* 277: 1666–1669.

Mayr, E. 1942. *Systematics and the Origin of Species from the Viewpoint of a Zoologist.*: Columbia University Press, New York.

Mayr, E. and Diamond, J. 2001. *The Birds of Northern Melansesia: speciation, ecology, and biogeography*. Oxford University Press, Oxford.

Rambaut, A. and Bromham, L. 1998. Estimating divergence dates from molecular sequences. *Molecular Biology and Evolution* 15: 442–448.

Sibley, C. G. and Ahlquist, J. E. 1990. *Phylogeny and Classification of Birds. A study in molecular evolution.* Yale University Press, New Haven, CT.

Zink, R. M., Klicka, J. and Barber, B. R. 2004. The tempo of avian diversification during the Quaternary. *Philosophical Transactions of the Royal Society of London Series B* 359: 215–220.

Redefining the Quaternary

From the Editor

The International Commission on Stratigraphy (ICS) recently moved to formally eliminate the Quaternary from the Geological Time Scale. Reproduced here are open letters to the Quaternary community written in April 2004 by the INQUA executive and the president of INQUA's Stratigraphy and Chronology Commission, Dr Brad Pillans, alerting Quaternarists to the significance of this impending change. Brad's proposal, which seeks to preserve a formal status for the Quaternary, was also offered for comment, and is reproduced here. It is followed by a synthesis of responses received near the time of publication of this issue. Also included is an update from John Clague, stating the formal positions of INQUA and The International Association of Geomorphologists. Finally, a New Zealand perspective on Quaternary stratigraphy and its bearing on the definition of a lower period/subperiod boundary is provided by Naish, Beu and Alloway.

— K. Sniderman

From the INQUA executive

Colleagues,
The International Commission on Stratigraphy (ICS), under the auspices of IUGS and ICSU, is revising the Geological Time Scale. A proposed revision of great consequence to the Quaternary community is an extension of the Neogene System to the present. The Pleistocene and Holocene would be retained as Series, but the Quaternary would be eliminated as a System. An argument made by ICS is that the 'Quaternary' and 'Tertiary' are archaic terms. Elimination of Quaternary as a System is clearly a highly charged issue, but ICS seems determined to make the change, whether or not Quaternarists agree.

INQUA does not accept the elimination of the word 'Quaternary' from the Geological Time Scale. Accordingly, its Commission on Stratigraphy and Geochronology has suggested a compromise to the INQUA Executive Committee that may or may not be acceptable to both the larger Quaternary community and ICS (see letter and proposal by Brad Pillans). The gist of the proposal is to define a Quaternary Subsystem that encompasses the present Pleistocene and Holocene Series, as well as the Gelasian Stage (2.6–1.8 Ma). Under this proposal, the boundaries of the Pleistocene and Holocene would remain unchanged.

The INQUA Executive Committee asks for your feedback on this important issue. Please send your comments to John Clague (jclague@sfu.ca) and Brad Pillans (brad.pillans@anu.edu.au).

— INQUA Executive Committee
John J. Clague, Nicholas Shackleton, Peter Coxon, Margaret Avery, Allan Chivas, Jan Piotrowski, Denis-Didier Rousseau and An Zhiseng

From Brad Pillans

The Geological Time Scale (GTS) is one of the great achievements in Earth Sciences. Recent revisions and proposed revisions are part of the ongoing mandate of the International Commission on Stratigraphy (ICS) — see www.stratigraphy.org.

One of the proposed revisions of the GTS is to extend the Neogene System (Period*) up to the present, thereby subsuming what is currently the Quaternary System (Period). While some may see this as a threat to the Quaternary, I see it as a wonderful opportunity to redefine the Quaternary in the way that we have wanted for some time — namely, to extend the base downwards from 1.81 Ma (Plio/Pleistocene boundary) to 2.6 Ma (base of Pliocene Gelasian Stage).

Let me speak plainly when I say that we (INQUA) have little hope of retaining the Quaternary System, above the Neogene System, as it is at present. The weight of support within ICS for extending the Neogene up to the present is too great. Furthermore, we have no hope of changing the Plio/Pleistocene boundary — we tried that in 1997–98, resulting in a most acrimonious debate between INQUA and ICS.

I believe that our best and only reasonable course of action is to grasp the opportunity presented to us and redefine the Quaternary as a Subsystem within the extended Neogene System, with base at 2.6 Ma. Indeed, I have been asked to submit such a proposal to ICS. The proposal below is a draft for comment/discussion and, perhaps, for endorsement by INQUA. As recommended by ICS, I have tried to keep the document short and to the point.

A strength of the proposal, I think, is that it decouples the base of the Quaternary from the 'blood sweat and tears' of the Plio/Pleistocene boundary.

The views expressed are my own, but I sense that they will be widely supported by Quaternary scientists. After all, this is a chance to extend our time domain by 800,000 years!

To reiterate, this may be a once-in-a-lifetime opportunity — we are unlikely to get another opportunity to define the Quaternary in the way we want it.

— *Brad Pillans*,
President INQUA Stratigraphy & Chronology Commission

* 'Period' is the geochronologic unit equivalent of the chronostratigraphic unit 'System'

Proposal to redefine the Quaternary

In the revised geological time scale (GTS2004) Gradstein et al. propose to extend the Neogene System (Period) up to the present, thereby making the Quaternary System (= Pleistocene + Holocene Series) redundant (see figure).

Here I propose that the Quaternary be redefined as a Subsystem (Subperiod) of the Neogene, and that its base be defined at the base of the Pliocene Gelasian Stage at 2.6 Ma (GSSP ratified — Rio *et al.* 1998. *Episodes 21*, 82.). After recent discussions by the ICS executive, in consultation with the IUGS executive, they have requested that the various formal stratigraphic groups of ICS and INQUA be asked to consider the proposal.

In support of the proposal for a Quaternary Subsystem (Subperiod), I note the following:

1. There is overwhelming support from INQUA members — who I have talked with — to retain the Quaternary as a formal chronostratigraphic unit.

2. There is precedence for naming Subsystems in the GTS, specifically the Mississippian and Pennsylvanian Subsystems of the Carboniferous.

3. Redefinition of the Quaternary will make use of an existing GSSP (Gelasian Stage).

4. Decoupling the base of the Quaternary from the Plio-Pleistocene boundary (1.8 Ma) would, I believe, bring an end to long-running arguments over the position of the Plio/Pleistocene boundary.

5. A majority of INQUA members appear to favour a 'long' Quaternary (2.6 Ma) over a 'short' Quaternary (1.8 Ma). In essence, the preference for a 'long' Quaternary reflects perceived continuity of character over that time. For example, around 2.6 Ma, Chinese loess deposition becomes widespread and is substantially different in character to the underlying Red Clay (e.g. Ding et al. 1997. *Quaternary International 40*, 53).

6. Around 2.6 Ma, deep sea oxygen isotope records show the culmination of a series of cycles of increasing glacial intensity, also associated with the first major inputs of ice-rafted debris to the North Atlantic. For many, this marks the beginning of the 'Quaternary ice ages'. It also marks a change from precession-dominated to obliquity-dominated climate forcing.

In summary, the extension of the Neogene System (Period) upwards provides an ideal opportunity to redefine the Quaternary as a Subsystem (Subperiod) of the Neogene. The proposal for a Quaternary Subsystem is consistent with popular usage, does not require a new GSSP and will end arguments about the Plio/Pleistocene boundary.

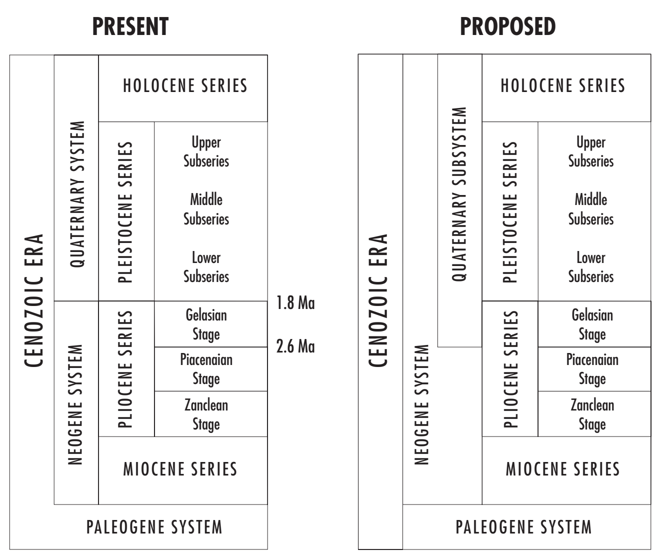


Figure 1 Chronostratigraphic units of the Cenozoic Era illustrating the proposed redefinition of the Quaternary.

Redefining the Quaternary – commentary on responses received by INQUA

Late last year, I discovered that the International Commission on Stratigraphy (ICS) was about to publish a new Geological Time Scale (Gradstein et al. *in press*) in which the Quaternary no longer had status as a formal chronostratigraphic unit. Indeed, the ICS web site (www.stratigraphy.org) stated that the Quaternary was considered to be '*the interval of oscillating climatic extremes (glacial and interglacial episodes) that was initiated at about 2.5 Ma, and therefore encompasses the Holocene, Pleistocene and uppermost Pliocene. It is not a formal chronostratigraphic unit*'. In other words, ICS was relegating the Quaternary to an informal climatostratigraphic unit.

Proposals to do away with the Quaternary and extend the Neogene System (Period) to the present, are not new (see Berggren et al., 1995, *GSA Bulletin* 107:1272). However, the ICS proposal appeared to be an officially sanctioned position, soon to proceed towards formal ratification. Furthermore, the proposal was apparently being made with little or no liaison with INQUA.

After discussion with the members of the INQUA executive committee at a meeting in Dublin in March this year, I put together a proposal to 'save' the Quaternary as a chronostratigraphic unit. The proposal was intended to be a compromise that would allow the extension upwards of the Neogene System and the creation of a Quaternary Subsystem within it. In proposing a Quaternary Subsystem, I took the logical step (logical to me, anyway) of proposing to extend the Quaternary from its currently defined base (1.8 Ma = Pliocene/Pleistocene boundary) to the base of the uppermost stage (the Gelasian Stage) of the Pliocene Series, at 2.6 Ma. In this way, the base of the Quaternary would be decoupled from the Plio/Pleistocene boundary, a boundary that has been a source of long-running discontent among Quaternarists (see papers in T.C. Partridge [ed.] *Quaternary International* 40).

In April 2004, my proposal was circulated to the email addresses of all participants at the Reno INQUA Congress in August 2003 (about 1000 people) and, at the instigation of Felix Gradstein (ICS President), placed on the ICS web site.

In the month or so since the proposal went public, I have received 70 email replies from individuals and organizations. This is not exactly an overwhelming response (less than 1%) to what I thought would be a 'hot topic'. On the other hand, replies are continuing to arrive and, I daresay, will continue to do so once the proposal has been widely discussed by various organizations and societies with interests in the Quaternary.

Let me summarise the nature of the responses so far received:

1. There is overwhelming support for retention of the Q as a formal chronostratigraphic unit (67 of 70 respondents support). Only 3 favour elimination of the Q as a chronostratigraphic unit.
2. Of those who favour retention of the Q, 60 support the proposal to redefine the Q as a Subsystem of the N, including extension of its base to 2.6 Ma. Another 2 favour extension of the Q to 2.6 Ma, but only as a System above the N. A further 2 favour the status quo (Q System, base 1.8 Ma), while 2 others did not state a preference.
3. There is an anti-ICS reaction among Quaternarists, ranging from mild discontent to outrage, over the apparent lack of communication between ICS and INQUA. This is an area of concern. I hope that full and open dialogue will henceforth occur between the two parties. ICS actively encouraged me to place the proposal on their web site (under 'News'), so things are looking up at this stage.
4. A question has been raised over the validity of not following the strict hierarchical arrangement of chronostratigraphic boundaries, whereby the base of the proposed Quaternary Subsystem would not correspond to a Series boundary at the next lower level of classification in the GTS. I hope we don't get bogged down with such pedantry, but move forward with a practical scheme that works rather than a theoretical scheme that doesn't. At this stage of the game, the president of ICS, Felix Gradstein, has lent his full support to the proposal, so I have to presume that the hierarchical technicality is not an issue.

I will not mention any names, but here is a selection of the comments received:

‘A brilliant solution to the age-old problems.’

‘Sometimes compromises are inevitable.’

‘I think that this is the right way forward.’

‘I really like Brad’s proposal.’

‘We recognize the logic of including the Gelasian.’

‘People are not going to stop using Quaternary just because some international commission drops it.’

‘What do you call the Neogene subsystem that precedes the Quaternary?’

‘There will be thousands of geologists that will sign a proposal to preserve the Quaternary’

‘To eliminate the term Quaternary would be difficult and only cause new problems. There are too many institutes, journals and even scientific disciplines — and INQUA! — containing this word to make it possible to do so. The fact that the term is archaic is no basis for such action. That is a very unscientific way of discussion. The survival of this term, contrary to Primary, Secondary and even Tertiary only demonstrates its vitality. I guess that Quaternarists will continue to use it whether ICS likes it or not.’

‘I doubt the ICS will see merit in it [the proposal] if they are on an ‘expunge archaisms’ jaunt. ICS will fail to see merit in it because they have blinded themselves to the reality that the Geological Time Scale (GTS) itself is an archaism, now that so many numeric dating methods are available.’

‘Eliminate the Holocene because it is indistinguishable from other Pleistocene interglacials.’

‘I wish to express through you my strong disapproval of the way ICS make these decisions almost in isolation without seriously discussing them with the large number of people (as represented by INQUA) who actually work on the deposits involved. The decision to place the Plio-Pleistocene boundary at the highly inappropriate, poorly defined and poorly dated point in the Vrica section was very much of this type. The solid refusal to reconsider it despite the numerous cogent arguments advanced by INQUA was the same, and now we are faced with a third arbitrary decision by a semi-detached committee, who are again prepared to pontificate, ignoring the considered opinions of what must be almost everyone who is intimately involved in the matter. I find this a quite intolerable way of proceeding, and I feel INQUA should now complain to ICSU, requesting that they insist ICS as part of IUGS act in a more democratic fashion. IUGS has got to realize that the sole control they are able to exert over the stratigraphy and study of earlier geological periods does not extend to the most recent period, in which numerous other non-geological scientific groups have a long-standing and growing interest.’

‘For me it is no option to degrade the Quaternary to a subsystem. The base of the Quaternary is another issue and we should not discuss that in relation to the maintenance of the term. So no comments on the base. NO SUBSYSTEM for the Quaternary.’

‘As an old friend of the Pleistocene, I think the best way to redefine the Quaternary is simply to dump it, totally, and at the same time reduce the status of the Holocene to what in reality it is — one of the Pleistocene interglacials.’

‘I think the Quaternary should be treated differently than the discarded Primary, Secondary, and Tertiary, simply because an entire field of scholarship and understanding has developed around the study of recent, mostly unconsolidated, sediments. The terms Quaternary geology, Quaternary studies, Quaternary laboratories, and the like are common phrases in geology and appear at the titles of programs, buildings, publications, and papers. This is unlike most of the other antiquated terms in the geologic time scale.’

‘As the forthcoming Editor of *Journal of Quaternary Science* it saddens me to see my journal potentially disappearing at the moment I take over.’

‘Just wanted to voice my support for the outlined change with the Quaternary as a subsystem encompassing the last 2.6 Ma. These changes would also make better use of the Neogene when communicating results — far too often I have found myself resorting to Late Cenozoic in the meaning of the Neogene + the Quaternary.’

‘As an archaeologist I am much in favour of the new definition of the Quaternary. This means that the entire history of humans as tool makers would be enclosed in the new system.’

‘We are very much in favour of your proposal. Like many others, for a long time we have accepted 2.6 million years as the only defensible lower boundary for the Quaternary, while being uneasily aware that there was no widespread agreement about this. Your solution neatly avoids the problem by permitting those who have a primary interest in high frequency climate change and its consequences to continue with a re-defined and much more usuable Quaternary definition, while leaving those more concerned with other aspects of the earth system with a nomenclature that suits them. Well done.’

‘I find it incredibly arrogant that a group of workers who will not mainly be working in the Quaternary get to ride roughshod over the wishes of thousands of

Quaternary Scientists. One of the defining aspects of the science of the Quaternary is its multidisciplinary nature. It has always struck me as anomalous that a group (ICS) to which probably less than half of all Quaternary workers have any affiliation to, has the ability to legislate for our community. If ICS pushes through with its changes without accepting a compromise of the type that Brad proposes, I will take the only protest path that I have available to me and resign from any IUGS affiliated organizations to which I belong. The need for INQUA to stand alone and away from IUGS in ICSU is doubly reinforced.'

'I consider it highly desirable to retain the term Quaternary, despite its archaic roots, and the opportunity to break with the rigid Plio-Pleistocene boundary is irresistible.'

'Perhaps the proposal to redefine the Quaternary as a subsystem that includes the Holocene, Pleistocene, and the latter part of the Pliocene is the best we can hope for in these circumstances. However, because such a construct would produce a subsystem that bridges only a portion of the Pliocene (the Gelasian), I am concerned that many would object because it looks somewhat artificial. Is there a precedent for this?'

'I am wholly in support of your strategy to preserve the Quaternary. ICS runs the risk of losing the support of an important community and prompting a split in stratigraphic usage that may continue *ad infinitum*. Neither is desirable.'

'I take a dim view under the best of circumstances of taxonomists of one stripe or another dictating terms to people they haven't consulted. In the case of the journal, I think a better name would be *The Journal Formerly Known As Quaternary Research*. Later, we could have a contest to devise an iconographic symbol that we asserted meant the same thing, and retitle the journal with that.'

'Considering that the only other option is for the term "Quaternary" to go away, this seems like a reasonable proposal. If they dump Quaternary entirely, what are all those journals going to do? What do you think about '*Late-Neogene Research*' and '*Late-Neogene Science Reviews*'? Doesn't really cut the mustard.'

'The only bit of untidiness is the lack of parallelism of the Quaternary Subsystem with the Series boundaries (Pliocene-Pleistocene). For the 45 years of my career, there has been no good resolution of the Pliocene-Pleistocene boundary. Given that this is impossible to define without a huge minority dissent, we should let this sleeping dog lie, and pragmatically accept an age for the base of the Quaternary Subsystem (2.6 Ma) that differs from the base of the Pleistocene (1.8 or 1.65 Ma).'

'Brad is certainly trying to reach a compromise that will leave both sides in this sorry and unnecessary encounter with some sense of victory.'

'I cannot accept the suggestion that Brad has made. It would be perfect if it were not in reality very much the "thin edge of a very substantial wedge". My dealings with the ICS executive suggest strongly to me that they would be delighted if we accept Brad's idea because then the Pleistocene and the Holocene would be back precisely where they wanted them — in the Neogene.'

'The term "Quaternary" may be archaic, but at least it is relatively clear what it means. In contrast, the German version of "Neogene" (Neogen) means, according to the dictionary: "An alloy resembling silver, and consisting chiefly of copper, zinc, and nickel, with small proportions of tin, aluminium, and bismuth." No glaciers involved! The IUGS states that when the Neogene was defined by Hoernes he already included in 1853 the Quaternary in the Neogene. This statement is worthless, because (i) at that time the glacial theory was not yet accepted (see Dana 1863, Lyell 1863) and next to nothing was known about the Quaternary, and (ii) for good reasons for about 150 years nobody had followed Hoernes' proposal. It may be fashionable to introduce "hot" new terms, but I still consider Quaternary as being rather "cool" and would prefer to keep it that way. The new terminology may shine like silver, but to me it is only a cheap substitute.'

'I think your proposal makes a hell of a lot of sense. I especially like it because it gets INQUA out of the box of being considered just a sub-group of the IUGS which has been a big political obstacle to full INQUA membership in ICSU. The question is now whether the old farts that tend to occupy positions of power in INQUA will see the light.'

'I do very much appreciate your recognition of this situation as an opportunity to redefine the Quaternary as a subsystem with a 2.6 Ma base, and support the proposal wholeheartedly. Explaining the 1.7–1.8 Ma base is never easy, and moving it to 2.6 Ma would make the Quaternary "whole". Good work, and good luck with the ICS!'

'I agree with the desirability of the Gelasian being associated with the Quaternary, but it seems to me that by conserving its membership within the Pliocene series, you contradict a general principle of hierarchical taxonomy. In your proposal, the Pliocene series would span the boundary between two higher taxonomic categories, by straddling the Neogene system's boundary with its Quaternary subsystem! In biological taxonomy, this would be analogous to assigning a genus (Pliocene series) to a family (Neogene system), but placing one section of the genus (Gelasian stage) within a subfamily (Quaternary subsystem) to which the remainder of the genus does not belong; this is logically flawed, and in biological taxonomy the absurdity would be obvious. It is not clear to me whether the logic behind stratigraphic nomenclature fundamentally differs from that of biological taxonomy, so I have reservations about the proposal in its current form.'

'The comment that the ICS is determined to go ahead regardless of the opinions of Quaternarists strikes me as an appalling resurrection of the totalitarian state! Methinks that international science is becoming a Third World backwater!'

'The date for the base of the Pleistocene and Quaternary (1.8 Ma) has been an anachronism for some time now, and only politics has held back a more reasonable definition. I strongly support a definition of the Quaternary that spans the last 2.5 Ma or so. Do it!'

'I think that this is the right way forward. I have always resisted the idea of changing the Plio-Pleistocene boundary because this has been so consistently utilized over the past half-century by marine workers. But you are undoubtedly correct in saying that the majority of Quaternary workers would favour an older position for the base of the Quaternary, and to move the base of the Quaternary from the GSSP at the base of the Calabrian (top of the Gelasian), to the GSSP at the base of the Gelasian, would (as you say) achieve this.'

'In choosing the terminology of "Subsystem" (rather than "Subperiod") you are running against the current of another possible/likely change in international stratigraphic practices which is coming up. Which is the proposal by Zalasiewicz et al. in *Geology* 32, 1–4 to drop entirely the confusing and redundant category of time-stratigraphic (time-rock) units, and retain only the parallel time units. Such a change was argued for strongly about 30 years ago (amongst others, by me), but was too radical for the dominant American stratigraphers of the time. I believe (and certainly hope) that there will now be widespread support from young stratigraphers for the idea.'

'I can live with 2.6 Ma as a compromise because I (nihilistically) believe that there are no such things as "natural" points at which to insert GSSP or to define boundaries — the Plio/Pleistocene and base-Quaternary included. Indeed, it is a belief in such natural points, led largely by messianic biostratigraphers, which has led to the last 100 years of unproductive argument over the semantics of names.'

'The proposals to lower the lower Quaternary boundary cannot be correct (valid) because they contradict the previous decision of the ICS. They do not make the scale more stable. If we displace the adopted boundaries in accordance with changed views of some persons (these views have no scientific merits), we shall never reach the general stability. The more so that this concerns the destruction of neighboring systems (Pliocene). The scale is used not only for theoretical considerations, but also for practical purpose — geological mapping of both regional and subglobal magnitude.'

Brad Pillans
brad.pillans@anu.edu.au

The following is an extract of an open letter to Quaternarists from John Clague, INQUA Vice President, in June 2004

Revision of the Geological Time Scale: Implications for the 'Quaternary'

Dr. Pillans' proposal has been circulated to INQUA members and the larger community of earth scientists interested in the late Cenozoic and is included in next issue of *Quaternary Perspectives*. An alternative position, that we stand our ground and demand that the Quaternary be retained as a System separate and distinct from the Neogene, is presented in the same issue by Phil Gibbard, Chair of the ICS Subcommission on Quaternary Stratigraphy.

The INQUA Executive Committee is concerned that ICS has not consulted representatives of the Quaternary community about its changes to the late Cenozoic part of the time scale. It would be prudent for ICS to defer any changes to the 'Quaternary' until the Quaternary community has had time to more fully consider options and consequences. Consultation is in progress and will continue — with INQUA's support — at IGC in Florence this summer and at the next INQUA Congress in Cairns, Australia, in 2007.

The INQUA Executive Committee asks that ICS consider its formal position on this important issue and the similar position of the International Association of Geomorphologists (IAG), both of which are given below. Please express your views to the ICS Chairman (Felix Gradstein, felix.gradstein@nhm.uio.no) and Secretary General (James Ogg, jogg@purdue.edu), with a copy to John Clague, President of INQUA (jclague@sfu.ca).

Position of the INQUA Executive Committee on the proposed revision of the Geological Time Scale

INQUA insists that 'Quaternary' be retained as a formal unit in the new Geological Time Scale. The Quaternary is, in some respects, the most important period in earth history, a time of major climatic, oceanographic, and biotic changes, as well as the appearance and evolution of the human species. Its importance is reflected in the fact that it has a strong interdisciplinary union (INQUA), that it is appreciated by scientists outside of the geological sciences, and that it is a doorway through which new approaches and ideas are introduced into geology. 'Quaternary' is too important a term to be removed simply because it is may make the geological time scale tidier (the 'Primary' and 'Secondary' having been eliminated long ago, with the Tertiary shortly to follow). 'Quaternary' is the bridge between humans and geology. It provides an umbrella for bringing other important and fundable disciplines into the geological sciences.

In the interim, until this important matter is given full consideration by the Quaternary community, INQUA recommends that the 'Quaternary' be retained as a System separate from the Neogene, comprising the Pleistocene and Holocene (the status quo). If temporary retention of the status quo is unacceptable to IUGS, INQUA recommends that ICS formally adopt Brad Pillans' proposal that the Quaternary be a formal Subsystem of the Neogene, extending from the beginning of the Gelasian Stage of the Pliocene to the present. Through its consultation with the Quaternary community, the INQUA Executive Committee has found near-universal support for extending the Quaternary from its present lower boundary at 1.8 Ma to 2.6 Ma, the beginning of the Gelasian Stage. There is also widespread support for maintaining the 'Pleistocene' and 'Holocene' as formal Series.

The International Association of Geomorphologists shares INQUA's concerns and has issued the following official statement, which is consistent with INQUA's position:

The International Association of Geomorphologists (IAG) has considered the proposed revisions to the Geological Time Scale by the International Commission on Stratigraphy. **The IAG regrets the proposed elimination of the Quaternary as a system.** However, if this change does take place then it supports the idea that within the Neogene a Quaternary Subsystem is established with a long time-scale (i.e. the last 2.6 million years). This would remove problems with regard to the placing of the Plio-Pleistocene boundary, and would reflect the major changes in the global environment which took place at 2.6 Ma (as recorded both in loess sections and in the deep sea oxygen isotope record).

What does the term 'Quaternary' mean in New Zealand?: Historical usage and a way forward

Tim Naish, Alan Beu and Brent Alloway

Institute of Geological & Nuclear Sciences, Lower Hutt, New Zealand

Historical use of the Quaternary

The Pliocene-Pleistocene boundary in New Zealand has historically been placed at the earliest faunal evidence of climatic cooling in southern North Island sedimentary basins, as shown by the first occurrence of the subantarctic scallop *Zygochlamys delicatula*, commonly in association with the cool-water crab *Jacquinotia edwardsii* (Fleming 1953; Beu et al., 1987). In Wanganui Basin, this occurs at the base of the Hautawa Shellbed, which defines the base of the New Zealand Nukumaruan Stage SSP. When Fleming (1944) first drew attention to the paleoclimatic significance of *Z. delicatula*, several hundred kilometres north of its modern range, the Nukumaruan Stage was considered to be Pliocene in age. Subsequently, with the proposal of an international Pliocene-Pleistocene boundary at the horizon of first cooling in the Italian Neogene succession at the base of the Calabrian Stage in 1948, the way seemed clear to correlate the boundary to the base of the New Zealand Nukumaruan. Although such a correlation is widely attributed to Fleming (1953), he qualified the correlation by admitting that 'more evidence is desirable before such a step be taken' (p. 127). His qualification was apparently ignored and, after an internal review in 1953, the director of the New Zealand Geological Survey recommended that the Pliocene-Pleistocene boundary (L.I. Grange, internal memo) be correlated with the base of the Nukumaruan Stage, with the result that much of what had been considered Pliocene was now placed in the Pleistocene. Given the long historical association of the base of 'Quaternary' with the base of the European Calabrian Stage (Deperet, 1918) and its terrestrial correlative the Villafranchian Stage, the base of Quaternary in New Zealand was also tied to the base of the Nukumaruan at this time. Early palynological investigations in New Zealand (e.g. Couper and McQueen, 1954) showed evidence of significant cooling in rocks of Lower Nukumaruan age, including glacial deposits at Ross on the west coast of the South Island. The Lower Nukumaruan thus became firmly established within both marine and terrestrial sequences as representing the time of earliest Pleistocene cold (see also Gage and Suggate, 1958; Gage, 1961).

Biostratigraphic subdivision of the Quaternary in New Zealand (Fig. 1), largely based on endemic molluscan fauna, was recognised by Fleming as problematic, as many taxa — such as *Z. delicatula* — have interrupted ranges owing to fluctuating climatic conditions. These difficulties led to a range of non-paleontological criteria (evidence of glaciation, chronology based on eustacy) being employed to subdivide the Quaternary into a system of local stages (Fig.1). Historically, New Zealand Quaternary deposits were classified into two series equivalent to the Upper and Lower Quaternary. Sediments of the Upper Quaternary included the deposits of four major glacial advances on the South Island and intervening warm periods (Suggate, 1965). Those of the Lower Quaternary were thought to be closer in nature to preceding Pliocene sediments but contained paleontological and glacio-eustatic evidence for two broad cold and warm periods, with glacial deposits of one cold period being known in South Island (Ross Glacial). The biostratigraphic subdivisions of the Lower Quaternary were first proposed as substages of the Nukumaruan and Castlecliffian Stages (Fleming, 1953), but were later given stage status as the sequence Hautawan (cold), Nukumaruan (warm), Okehuan (cold) and Castlecliffian (warm). Upper Quaternary glacial sediments in the South Island were correlated with four glacial stages and four intervening interglacial stages (Fig. 1). Difficulties with the recognition outside of type localities meant that the substages were not widely used. Moreover, publication of the first oceanic oxygen isotope records (e.g. Shackleton and Opdyke, 1973) heralding the orbital theory of the ice ages (Hays et al., 1976) led to the recognition of a higher frequency glacio-eustatic cyclostratigraphy in the New Zealand Quaternary (e.g. Beu and Edwards, 1984), resulting in the eventual abandonment of climatically influenced substages (following the suggestion of Beu, 1969).

It is clear that the definition of Quaternary in New Zealand has its historical basis firmly entrenched in the paleontological, geomorphological and sedimentological recognition of the onset of major cooling and climatic fluctuations. However, age estimates for base of the Nukumaruan Stage based on early radiometric and fission track dates ranged from 2.2 to 2.6 Ma (Mathews and Curtis, 1966; Stipp et al., 1967). Kennett et al. (1971) also presented isotopic and faunal evidence of climate cooling in Wairarapa close to the Gauss-Matuyama (G/M) polarity transition (then dated at 2.43 Ma), but noted that the internationally accepted Pliocene-Pleistocene boundary at the base of the Calabrian Stage in Italy probably lay close to the base of the Olduvai (Gilsa) event at about 1.79 Ma. By the early 1970s, there was already considerable uncertainty about the age and position of the base of the Quaternary in New Zealand. This was partly because the internationally proposed Pliocene-Pleistocene boundary had yet to be rigorously defined and dated. With formal designation and characterisation of the GSSP in the Vrica section in southern Italy (Backman et al., 1983; Tauxe et al., 1983; Aguirre and Pasini, 1985), the way was open to establish the precise position of the boundary in New Zealand using all available techniques, but particularly biostratigraphy, tephrochronology and magnetostratigraphy of marine sediments in shallow marine North Island sedimentary basins. The magnetostratigraphy of the Pliocene-Pleistocene boundary stratotype at Vrica indicated a stratigraphic location for the boundary immediately above the top of the Olduvai Subchron. Early magnetostratigraphic and tephrostratigraphic studies in

Wanganui Basin (Seward et al., 1986) demonstrated that the base of the Nukumaruan Stage was closer to the G/M (2.43 Ma) polarity transition than it was to the top of the Olduvai Subchron (1.79 Ma). Subsequently, Beu and Edwards (1984) showed that the boundary, as defined at Vrica, lay within the middle of the Nukumaruan Stage, well above the Hautawa Shellbed. While never formally defined, the base of the Quaternary has continued to be linked to the Pliocene-Pleistocene GSSP. Since the late 1980s, the Quaternary Period in New Zealand has essentially been decoupled from the onset of major northern hemisphere glaciation and associated global climate fluctuations.

The current use of Quaternary

In a remarkable anticipation of the first high-resolution isotope records linking global ice volume and sea-level to Earth's orbital variations, Fleming (1953, fig. 62) recognised as many as 35 'fluctuations in Pleistocene sea-level' in Wanganui Basin. Unable to explain the origin of these water depth changes within the 'four glacial' European paradigm of the time, he turned to local crustal 'yo-yoing'. Armed with oxygen isotope records and sequence stratigraphy, we now recognise Fleming's 'base level' changes in Wanganui Basin as the product of 41 ka– and 100 ka–duration global glacio-eustatic sea-level cycles spanning oxygen isotope stages 100 (2.46 Ma) to 5 (0.125 Ma) (Naish et al., 1998) — a remarkably complete record of shallow-marine sedimentary cyclicity since the onset of major northern hemisphere glaciations (Fig. 2). The development of an astronomically tuned cyclostratigraphy for the 3 km thick shallow-marine late Pliocene-Pleistocene marine succession in Wanganui Basin, supported by glass-FT dates of tephra interbeds (i.e. Alloway et al. 1993; Pillans et al., 1994) allowed precise location of the base of the Quaternary in New Zealand, as defined at the Vrica stratotype (Naish et al., 1996). This lies 60 m stratigraphically below the Vinegar Hill tephra (1.75 0.13 Ma) in the upper part of the Olduvai Subchron, at the base of the shelf siltstone of the highstand systems tract of Wanganui Basin Sequence 17, corresponding to the top of interglacial Oxygen Isotope Stage 65 (Fig. 2). As currently defined, the Quaternary encompasses the upper part of the Nukumaruan (2.40 to 1.63 Ma), Castlecliffian (1.63–0.34 Ma) and Haweran (0.34 Ma to present) stages (Beu, 2001). However, because of the historical association of the Quaternary in New Zealand with the onset of climatic deterioration at around 2.5 Ma, many Kiwi 'Quaternarists' have continued to extend their use of Quaternary to the base of the Nukumaruan Stage (Hautawa Shellbed = MIS Stage 98–97). There is no faunal or sedimentological expression of major climate change at the Pliocene-Pleistocene boundary in the New Zealand region. This led Naish et al. (1997) to support renewed discussions within the INQUA Commission of Stratigraphy to lower the Pliocene-Pleistocene boundary to a level near the Gauss-Matuyama polarity transition, and to propose the Rangitikei valley section in Wanganui Basin as a southern hemisphere reference (published in the special issue of *Quaternary International* on the

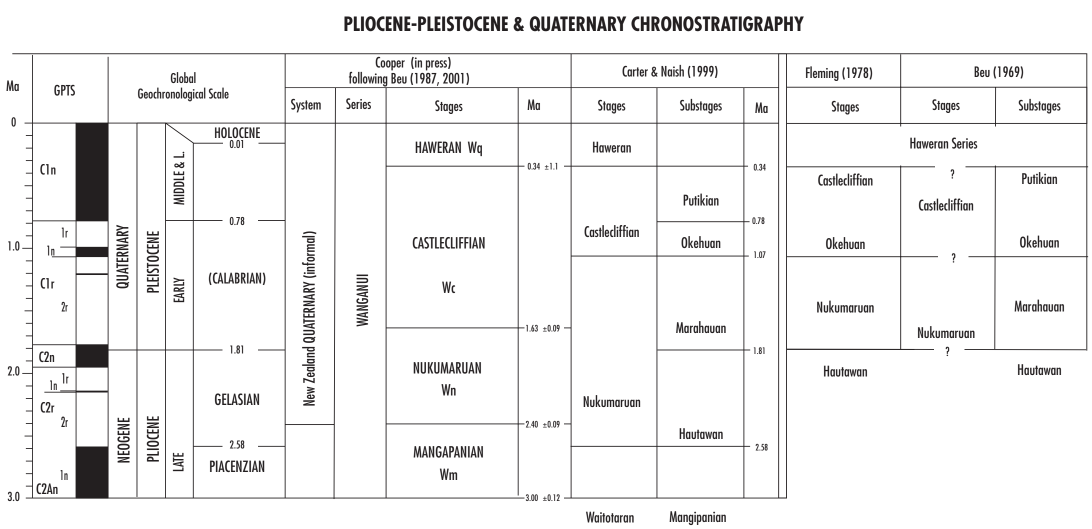


Figure 1 History of the chronostratigraphic subdivision of Plio-Pleistocene and Quaternary sedimentary deposits in New Zealand.

Pliocene-Pleistocene boundary). Recent ratification of the Vrica GSSP by the International Commission on Stratigraphy (ICS) has fixed the Pliocene-Pleistocene Boundary at 1.81 Ma, for the next 10 years at least.

On the future use and definition of Quaternary

The definition of 'Quaternary' remains a grey area. While there are strong historical precedents for its usage, extending to the early 18th century (e.g.

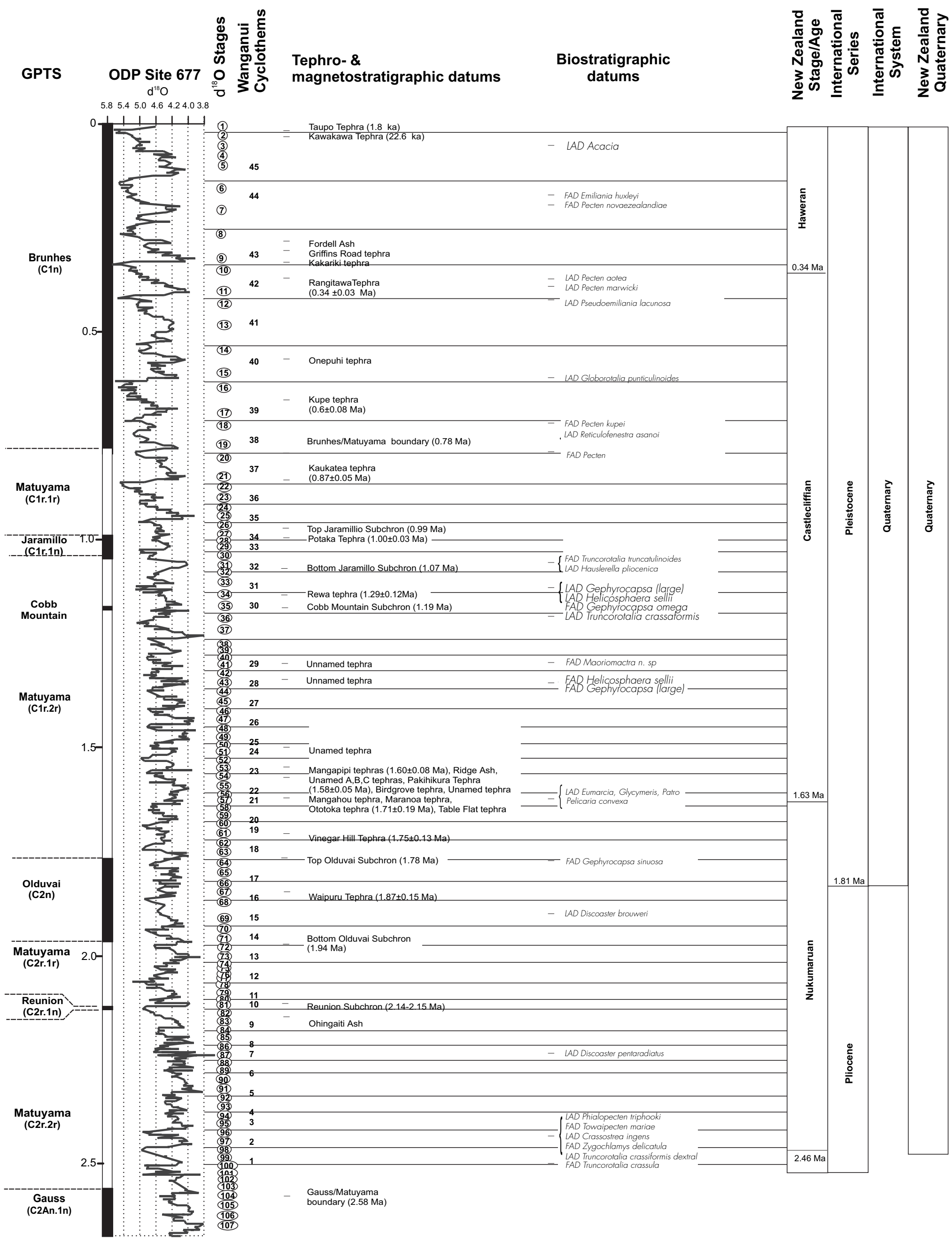


Figure 2 Integrated chronostratigraphy for "Quaternary" shallow-marine sediments, Wanganui Basin.

Desnoyers, 1829; Gignoux, 1910, 1913), the term has never been formally defined as a chronostratigraphic unit. A number of classification schemes have seen the Quaternary used as a system or period above the Neogene. However, many believe that the Quaternary is not a satisfactory term, as the original hierarchy of Primary and Secondary have been replaced by Paleozoic and Mesozoic respectively, and Tertiary has been replaced by Paleogene and Neogene. The ICS currently considers the 'Quaternary' informally as an interval of oscillating climatic extremes (glacial-interglacial episodes) that was initiated at about 2.5 Ma, encompassing the Holocene, Pleistocene and uppermost Pliocene. This fits well with the current usage of many New Zealand Quaternary stratigraphers. In the revised geological timescale (GTS2004), Gradstein et al. propose to extend the Neogene System (Period) to the present, thereby making the Quaternary System redundant. By way of a compromise, Brad Pillans has proposed to redefine the Quaternary as a Subsystem (Subperiod) of the newly defined Neogene and that its base be defined as the base of the Pliocene Gelasian Stage at 2.6 Ma (GSSP ratified — Rio et al. 1994). Pillans argues that redefinition of the Neogene System provides an opportunity to formally define the Quaternary for the first time in a way that is consistent with its historical and popular usage. His proposal is certainly consistent with the philosophy and practise of more than half a century followed by the vast majority of New Zealand Quaternary stratigraphers. It recognises the paleoclimatic significance of the time interval. It has the added benefit that it may put an end to the sterile and now rather futile debate over the Pliocene-Pleistocene boundary.

So finally, we ask the question, 'what is in a name?' Will the formal definition of the Quaternary advance our science or improve the communication of our science? Will we remain 'Friends of the Pleistocene?' Does the inclusion of the Quaternary as a chronostratigraphic unit provide a more useful means of subdivision and correlation of young geologic strata than the currently defined International Series and Stages? Or are endeavours to 'save the Quaternary' really rooted in more emotive issues such as the need to define a handle for a group of multidisciplinary researchers focused on the last 2.5 Ma of Earth's history and, in doing so, provide a sense of belonging and identity? Quaternary still means many different things to many people and it is unlikely that everyone will be pleased with a definition linking it to the base of the Gelasian Stage. If one wanted to play devil's advocate, one could say that we already have a perfectly useful GSSP at the base of the Gelasian tied to the G/M polarity transition and oxygen isotope stage 104 which marks the onset of major 'Quaternary' climate fluctuations. The counter to this is the idea that we may need a higher order of unit that spans the late Neogene 'glacial world'. These are important questions that will be discussed by ICS, the INQUA Commission on Stratigraphy and its members as they consider the Pillans proposal. Though these might be tough questions to answer, in New Zealand we like the term Quaternary. We have used it for many years, it is like an old friend to us and we know what we mean when we use it. After all, don't we have an impressive range of Quaternary sediments in New Zealand … and are they not world class?! Without wanting to appear flippant, we support Brad Pillans' endeavour to formalise the term. It should improve communication amongst Quaternarists and, at the very least, will allow us to keep on crowing about our world class 'Quaternary' stratigraphy!

References

Aguirre, E. and Pasini, G. 1985. The Pliocene-Pleistocene boundary. *Episodes*, 8: 116–120.

Alloway, B. V., Pillans, B. J., Sandhu, A. S.and Westgate, J. A. 1993. Revision of the marine chronology in Wanganui Basin, New Zealand, based on the isothermal plateau fission-track dating of tephra horizons. *Sedimentary Geology*, 82: 299–310.

Backman, J., Shackleton, N. J. and Tauxe, L. 1983. Quantitative nannofossil correlation to open ocean deep-sea sections from Pliocene-Pleistocene boundary at Vrica, Italy. *Nature*, 304: 156–158.

Beu, A. G. 1969. Index macrofossils and New Zealand Pliocene and Pleistocene time-stratigraphy. *New Zealand Journal of Geology & Geophysics*, 12: 643–658.

Beu, A. G. 2001. Local stages to be used for the Wanganui Series (Pliocene and Pleistocene), and their means of definition. *New Zealand Journal of Geology & Geophysics*, 44: 113–125.

Beu, A. G. and Edwards, A. R. 1984. New Zealand Pleistocene and late Pliocene glacio-eustatic cycles. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 46: 119–142.

Beu, A. G., Edwards, A. R. and Pillans, B. J. 1987. A review of New Zealand Pleistocene stratigraphy, with emphasis on the marine rocks. *In:* Itihara, M. and Kamei, T. (eds). *Proceedings of the First International Colloquium on Quaternary Stratigraphy of Asia and Pacific Area, Osaka, 1986*. INQUA Subcommission on Quaternary Stratigraphy of Asia and Pacific Area and National Working Group of Quaternary Stratigraphy, Science Council of Japan., Osaka, 250–269.

Carter, R. M., Naish, T. R. 1998. Have local stages outlived their usefulness for the New Zealand Plio-Pleistocene? *New Zealand Journal of Geology and Geophysics*, 41: 271–279.

Cooper, R. A. (ed.), 2004 (in press). The New Zealand Geological Timescale. *Institute of Geological and Nuclear Sciences Monograph* 22.

Couper, R. A. and McQueen, D. R. 1954. Pliocene and Pleistocene plant fossils of New Zealand and their climatic interpretation. *New Zealand Journal of Science & Technology*, B35: 398–420.

Deperet, Ch. 1918. Essai de coordination chronologique des tempes Quaternaries. *Comptes Rendus de l'Academie des Sciences*, 166: 480–486.

Desnoyers, J. 1829. Observations sur un ensemble de depots marins plus recent que les terrains tertiaries du basin de la Seine, et constituent une formation geologique distincte: precedes, d'une apercu de la non-simulaneite des bassins tertiaries. *Annales Sciences Naturelles, Paris*, 16: 171–214, 402–491.

Fleming, C. A. 1944. Molluscan evidence of Pliocene climatic change in New Zealand. *Transactions of the Royal Society of New Zealand*, 74: 207–220.

Fleming C. A. 1953. Geology of Wanganui Subdivision. *New Zealand Geological Survey Bulletin*, 52: 362 pp.

Fleming, C. A. 1978. The Quaternary record in Australia and New Zealand. *In:* Suggate, R.P. and Cresswell, M. M. (eds). Quaternary studies. Selected papers from IX INQUA Congress, Christchurch, New Zealand 2–10 December 1973. *Royal Society of New Zealand Bulletin*, 13: 1–20.

Gage, M. 1961: New Zealand glaciations and the duration of the Pleistocene. *Journal of Glaciology*, 3: 940–943.

Gage, M. and Suggate, R. P. 1958. Glacial chronology of the New Zealand Pleistocene. *Geological Society of America Bulletin*, 69: 589–598.

Gignoux, M. 1910. Sur la classification du Pliocene et du Quaternarie dans l'Italie du Sud. *Comptes Rendus de l'Academie des Sciences*, 150: 841–844.

Gignoux, M. 1913. Les formations marines du Pliocenes et Quaternaries de l'Italie du Sud et de la Sicile. *Annales Université Lyon, n.s., I–36,* 693 pp. Impr. A Rey Lyon.

Gradstein, F. M., Ogg, J. G., and Smith, A. G. 2004. *A Geological Timescale 2004*. Cambridge University Press (in press).

Hays, J. D., Imbrie, J. and Shackleton, N. J. 1976. Variations in the Earth's orbit: pacemaker of the ice ages: *Science*, 194: 1121–1132.

Kennett, J. P., Watkins, N. D. and Vella, P. P. 1971. Paleomagnetic chronology of Pliocene — Early Pleistocene climates and the Plio-Pleistocene boundary in New Zealand. *Science*, 171: 276–279.

Matthews, W. H. and Curtis, G. H. 1966. Date of the Pliocene-Pleistocene boundary in New Zealand. *Nature*, 212: 979–980.

Naish, T. R., Kamp, P. J. J., Alloway, B. V., Pillans, B. J., Wilson, G. S. and Westgate, J. A. 1996. Integrated tephrochronology and magnetostratigraphy for cyclothemic marine strata, Wanganui Basin: Implications for the Pliocene-Pleistocene boundary in New Zealand. *Quaternary International*, 34/3: 29–48.

Naish, T. R., Pillans, B. and Kamp, P. J. J. 1997. Recurring global sea-level changes recorded in shelf deposits near the G/M polarity transition, Wanganui Basin, New Zealand: Implications for redefining the Plio-Pleistocene boundary, *Quaternary International*, 40: 61–72.

Naish, T. R., Abbott, R. T., Alloway, B. V., Beu, A. G., Carter, R. M., Edwards, A. R., Journeaux, T. D., Kamp, P. J. J., Pillans, B. J., Saul, G. and Woolfe, K. J. 1998. Astronomical calibration of a Southern Hemisphere Pliocene-Pleistocene reference section, Wanganui Basin, New Zealand. *Quaternary Science Reviews*, 17: 695–710.

Pillans, B. J., Roberts, A. P., Wilson, G. S., Abbott, S. T. and Alloway, B.V. 1994. Magnetostratigraphic, lithostratigraphic, and tephrostratigraphic constraints on Lower and Middle Pleistocene sea-level changes, Wanganui Basin, New Zealand. *Earth and Planetary Science Letters*, 121: 81–98.

Rio, D., Sprovieri, R. and di Stefano, E. 1994. The Gelasian Stage: a proposal of a new chronostratigraphic unit of the Pliocene Series. *Rivista Italiana di Paleontologia e Stratigrafia*, 100: 103–124.

Seward, D., Christoffel, D. A. and Lienert, B. 1986. Magnetic polarity stratigraphy of a Plio-Pleistocene marine sequence of North Island, New Zealand. *Earth and Planetary Science Letters*, 80: 353–360.

Shackleton, N. J. and Opdyke, N. D. 1973. Oxygen isotope and palaeomagnetic stratigraphy of equatorial Pacific core V28–238: oxygen isotope temperatures and ice volumes on a 105 and 106 year scale. *Quaternary Research*, 3: 39–55.

Stipp, J. J., Chappell, J. M. A. and McDougall, I. 1967. K/Ar age estimate of the Pliocene-Pleistocene boundary in New Zealand. *American Journal of Science*, 265: 462–474.

Suggate, R. P. 1965. Late Pleistocene geology of the northern part of the South Island, New Zealand. *New Zealand Geological Survey Bulletin*, 77. 91 pp.

Tauxe, L., Opdyke, N. D., Pasini, G. and Elmi, C. 1983. Age of the Pliocene-Pleistocene boundary in the Vrica section, southern Italy. *Nature*, 304: 125–129.

A NEW INQUA PALAEOCLIMATE PROJECT:

'Land-Ocean Correlation of Long Records from the Southern Hemisphere at Orbital and Sub-Orbital Scales'

Introduction

In my capacity as Secretary of the new Commission on Palaeoclimate, I have been encouraged to become involved in project formulation. This proposal, that leads on from a previous southern hemisphere initiative, was submitted to the INQUA Executive Committee meeting in March and has been accepted as an official INQUA project for the inter-INQUA period (2003–2007). However, the precise nature and aims are totally open to discussion and modification. I would be pleased to receive comments on the proposal and particularly from those who would like to be involved in its final formulation and in its execution. There is the possibility of the project being expanded into a sub-commission and certainly there is the expectation that it will continue beyond 2007.

Rationale and aims

This project is proposed in response to growing interest in the particular climatic history of the southern continents and oceans. As a result of their association with ENSO and monsoon generation, and their role in the global thermohaline circulation, the southern oceans are critical to an understanding of global climate change. In terms of terrestrial palaeoenvironments, an understanding of long-term environmental change on the southern continents is still in its formative stages as proxy records are both spatially diffuse and temporally discontinuous. Further, an increasing awareness of major inter- and intra-hemispheric disparities in the timing of climatic signals and forcing influences between land and ocean records underscore the need for an integrated effort to explore the palaeodynamics of southern hemisphere systems.

In order to address these issues, the following aims are proposed:

1. To determine the present state of knowledge on the nature and location of land and ocean records covering a substantial part of the Quaternary and make a preliminary assessment of regional and temporal variability. Most data will probably relate to the last glacial cycle (and essentially extend the period of interest covered by INTIMATE initiatives). However, some coverage to at least 500 ka is considered essential to examine the nature and causes of the Mid-Bruhnes event that has been identified from the Pacific and Indian Oceans and may have altered atmospheric and climate circulation patterns in the region and, in the case of the SW Pacific, led to a trend of increasing variability that had major impacts on terrestrial climate and vegetation. Coverage of the whole Quaternary would be desirable to examine causes of suggested variation in times and patterns of change within the southern hemisphere and between the two hemispheres in the Early Pleistocene and around the Early-Mid Pleistocene boundary.
2. To identify critical gaps or areas on uncertainty and encourage and facilitate development of research proposals to fill them, particularly through involvement of the IODP and the Continental Drilling Program.
3. To encourage and facilitate closer collaboration between marine and terrestrial researchers, especially in examination of land and marine climate proxies within the same cores.
4. To generate and compile a potentially exciting data set amenable to modelling as a means of better understanding controls over southern hemisphere climates and the roles of the tropics and Antarctica in forcing global climate change.

Methods/approach

Now is an opportune time to start bringing information together for the southern hemisphere, because there is a great deal of activity by groups working largely independently who, hopefully, will welcome greater interaction. On land, the Continental Drilling Program has recently been employed to produce long cores from previously inaccessible areas or water depths, such as Lake Titicaca in South America and the rift valley lake of Africa, that extend into the southern hemisphere, while research on long continuous records is being actively pursued and supported within Australia and, recently, in New Zealand. Collaboration on techniques of analysis and particularly on dating would be invaluable to ensure independent chronologies on terrestrial sites and avoidance of what have been somewhat misleading correlations with the marine stratigraphy. In the marine realm, exciting results are emerging from combined marine-terrestrial proxy studies off Southern America, with preliminary research off southern Africa at last providing some clarification of climate patterns in this region. These results are beginning to relate to those from more established studies off more tropical West Africa and from terrestrial studies in the south-western Cape. Intensive study of terrestrial and marine proxies in the southern tropics of the northern-Australian Indonesian region is revealing complex relationships with forcing from the North Atlantic, Indian and Pacific Ocean regions that cry out for comparison with the other areas.

Because of the distances involved between study areas within the southern hemisphere and between research participants who are resident in both hemispheres, it may be necessary to establish a number of groups that can collate and direct research from different regions. However, it would be extremely valuable to have at least two general gatherings. The first, within the next year, could be used to assess the present state of knowledge and perhaps be formalised in the production of a multi-authored regional synthesis paper. This meeting could also provide the basis for the establishment of regional and specific scientific issue study groups, as well as identification of profitable areas for future study and facilitation of support for them. The second gathering could be for the presentation of new material and developments. It could also serve as a planning meeting for a symposium at INQUA 2007 and determination of future directions.

Suggestions are sought for appropriate meeting venues. Some seed money is available and could be used to attract funding sufficient for a stand-alone meeting. However, a more feasible option might be to combine the meetings with other smallish relevant gatherings to maximise their attraction.

One possible option is the final conference of the DEKLIM-EEM programme, to be held at Mainz, Germany, in March, 2005 (see Forthcoming Conferences and Meetings, p. 39), as a number of potential associates are from Germany or have been participants in the DEKLIN-EEM meetings. DEKLIM-EEM's focus on past interglacials, abrupt events and their value for prediction of future climate, as well as the mix of marine, terrestrial, ice workers and modellers, is highly relevant to our project.

A second meeting could be held in association with the Southern Connection conference, planned for Adelaide at the end of 2006. Southern Connection is perhaps the only relevant organisation that focuses on the southern hemisphere. It has held its triennial meetings in Australia, New Zealand, South America and South Africa. Quaternary climates have figured prominently at each meeting.

Anticipated outcomes

A much more coherent picture of southern hemisphere climate change and its drivers will totally alter perceptions on global climates and contribute substantially to understanding of the development of present landscapes. Meetings and proposed publications will cement a presently disparate research community and provide a base for long-term collaboration.

I welcome any suggestions, criticisms and especially expressions of interest in being involved.

Peter Kershaw
School of Geography and Environmental Science,
Monash University, Vic. 3800, Australia
Email: Peter.Kershaw@arts.monash.edu.au

IV Southern Connections Conference, University of Cape Town, South Africa, January 2004

Stuart Pearson

Geography and Environmental Science
University of Newcastle, Callaghan, NSW

'A very successful international conference was held from 19–24 January 2004 at the University of Cape Town. 328 delegates attended from 18 countries and 156 papers were presented during the week. A large selection of posters were also displayed.

Southern Connections is a large group of scientists from all continents who study aspects of biology and earth history of the Southern Continents — it meets every 3–4 years. The theme was Towards a Southern Perspective. One of the main aims of Southern Connections is to develop and emphasise differences between North and South Africa, for example, with its long history of hominids and its relatively well preserved megafauna, is a stark contrast to most of the Northern Hemisphere. Besides this theme there were several other more specific themes relating to, for example, ecology, biogeography, phylogeny, phylogeography, history and utilization.'

http://web.uct.ac.za/conferences/sc2004/index.html

The Conference was very diverse and the concurrent sessions were relentlessly attractive, driving people to excess. The plenary speakers — Ian Woodward, Peter Cranston, Kevin Gaston and Steven Chown — were a bit more awkward as they tried to keep their topics broad. Some of the sessions gathered the range of players. As you can imagine, the 'Fire and biogeography of southern temperate regions' symposium was hotter than hot. Some of the papers I enjoyed most were the ones I went to almost by mistake: Alexey Solodovnikov's paper on a genus of beetle was great, and Steven Chown's plenary described how increasing scientific visits increased invasive species arrivals in the southern islands (one species per 116 visits). Overall, the modelers, geneticists and managers all mingled productively and made new connections.

The mid-conference breakout tours were great; a chance for a swim and also to see Australian weeds, such as Acacia, overwhelming the local Bitou Bush. Kirstenbosch Gardens was a wonderful venue for the launch of the Global Invasive Species Programme (http://www.gisp.org). The cloud-draped Tablemountain formed a great backdrop to the Conference and walks. My highlight was seeing hyrax (small African herbivores that build middens of organic material) but the Fynbos and Karoo vegetation were a close second/third. Peter Kershaw developed a close friendship with a local bird — see the conference web site for details about his ostrich.

It would be good to have the conference papers and poster abstracts on line — I've just sent a request. The next conference is in Adelaide (www.southern connection.org.au/fram) and I think it will be another great meeting.

Southern Connections Karoo Tour 24–28 January, 2004

Merna McKenzie

School of Geography and Environmental Science,
Monash University, Victoria 3800, Australia.

After a busy week at the Southern Connections 2004 conference in Cape Town, South Africa, an international group with representatives from Japan, Germany, Poland, Australia and New Zealand set out on the post-conference Karoo tour. Jasper Slingsby, our very knowledgeable tour guide, kept us well informed and as much on schedule as was possible for a disparate group with very varied and wide-ranging interests and a pronounced tendency to ignore time and disappear in different directions. Jasper, who was very familiar with the areas we visited, had just completed his undergraduate degree and for his Honours Degree was undertaking a project on a group of the Restionaceae.

The itinerary traversed parts of the Cape Floristic Region, regarded by some as the world's sixth floral kingdom and the only one encompassed entirely within a single country. It displays high plant endemism of 69% and is one of the world's richest regions in terms of botanical diversity, with approximately 9,000 species of vascular plant. The Region lies at the southernmost tip of Africa, stretching in an L-shape from Vanrhynsdorp and Nieuwoudtville in the west, along the west coast of South Africa to Cape Town and then eastwards to Grahamstown. The Mediterranean-type climate has a winter rainfall, with elements of five different biomes: Fynbos (the most common), Succulent Karoo, Nama Karoo, thicket and forest.

After leaving Cape Town, we headed to the West Coast National Park to examine Sandveldt vegetation with scattered low shrubs and succulents of Mesembryanthaceae and Euphorbiaceae growing on the typically nutrient-poor sandy soils. A nearby limestone outcrop on the coast supported Strandveld, an open, scrub vegetation with several woody members and a high proportion of succulents and plants which produce fleshy fruits. Although we did not see it, *Chrysamthemoides monilifera*, which Victorians know as Boneseed — a scourge in many of our National and State Parks — occurs in Strandveld. Our next stop was to observe Renosterveld vegetation, which is characterized by a grey shrub called renosterbos or rhinoceros bush (*Elytropappus rhinocerotis*, Asteraceae) with an understorey of mainly monocotyledonous geophytes. The typical Fynbos families Restionaceae, Proteaceae and Ericaceae are scarce, although grasses are sometimes abundant. When rainfall is high — in excess of 600mm per annum — Renosterveld is replaced by Fynbos. When annual rainfall decreases to 250mm, it is replaced by Succulent Karoo vegetation. Little of the original Renosterveld now remains, due to clearing for agriculture.

After lunch at Kraalbaai, we visited the site of the footprints of Eve, which have been removed and now reside in the South African Museum in Cape Town.

The next morning we visited the West Coast Fossil Park at Langebaanweg, a dry windswept sandy area with sparse vegetation. The settlement at Langebaanweg achieved recognition due to the nearby presence of economically important phosphate deposits and an important military airbase. A 14 hectare fossil-rich area within the mine property was declared a National Monument in 1996 and has been developed for eco-tourism and as an educational resource. The systematic investigation of fossils and the deposits in which they occur is the main undertaking of the South African Museum's Department of Cenozoic Paleontology. Ongoing multidisciplinary research projects are undertaken between the Museum and other scientific institutions. The research facilities are utilized by local and international researchers.

This area is one of the most prolific sources of late Tertiary vertebrate fossils. Beneath the barren surface, 65m of marine and terrestrial sediments of Miocene and Pliocene age rest on the local bedrock. The Pliocene elements in the succession include the most important of the phosphate ore bodies as well as the largest assemblage of fossils recovered to date. One particular quarry has been painstakingly excavated and, as it has been found that the local pattern of sea-level change is in remarkably close agreement with the global pattern, it is possible to correlate southern African Tertiary succession, including Langebaanweg, with others elsewhere. During the Early to Middle Miocene, the only recorded fossils are plant remains, mainly pollen, which indicate the presence of marshes and forests, including tropical forms such as palms. During a long period of little or non-deposition of sediments, only a few fragmentary remains of terrestrial vertebrates were recovered. This was succeeded by the early Pliocene transgression, at which time the most important element in the Langebaanweg succession, the phosphatic and fossiliferous Varswater Formation — one of the most studied and best understood Tertiary sequences in southern Africa — was deposited. About 200 species of invertebrate and vertebrate animals have been recorded from this formation so far. Apart from the great variety of animals, the formation contains an astonishing quantity of fossils. Of the vertebrate fossils, the mammals of the deposits are the most intensively studied. These include several groups that no longer have living representatives south of the Sahara, such as bears, true seals, wolverines, and musk oxen as well as several other groups that are extinct, such as sabre-toothed cats and *Agriotherium africanum*, an enormous carnivorous bear. The restriction in distribution or extinction of these animals is ascribed to the environmental changes that occurred during the Pliocene. Plant remains are limited to occasional unidentified root fragments, microscopic spores and pollen of higher plants preserved in great numbers. These include Fynbos vegetation types similar to those found in this vegetation in the southwestern Cape today. We saw the active excavation site where fossil bones were crowded together in situ. Material from the site was being sieved and we were given the opportunity to attempt identification of any fossil material held by the sieves. This visit was one of the many highlights of our tour.

We travelled through some spectacular mountains and incredible rock formations over the Pakhuis Pass before arriving at Traveller's Rest, 34km from Clanwilliam. After settling into our fully equipped cottages (electricity, fridge, stove, crockery, cutlery, bedding etc — a palynologist's idea of field trip heaven), we had an enormous and very sociable meal at the Khoisan kitchen, a building on the Brandewyn River.

Up at 5am next morning to walk the Rock Art Trail for which Traveller's Rest is famous. The paintings (see p.23, and back cover) were the work of the San of Southern Africa, a group of people who were massacred, enslaved and absorbed until their culture was extinct. A wide variety of materials, including earth ochres, clay ash and bird droppings, formed the basis of the pigments. Although many of the paintings are very faded due to the passage of time, weathering and vandalism, some are well-preserved and provide a visual story of San beliefs and environment. The paintings are varied, representing both human and animal figures. A particularly interesting painting was a line of seven dancing women, showing the characteristic 'steatopygia' of the San, a physical characteristic in which women in particular were able to store fatty reserves of food in enormously enlarged buttocks. While the majority of the paintings represent people, a number of animals, probably representing hartebeest, zebra and antelope and others, are preserved.

The natural vegetation of the area is rich and varied, being a transition area of mixed Fynbos and Strandveld with many Karoo elements. During the walk we identified shrubs of a number of families, including Asclepiadaceae, Mesembryanthaceae (123 genera in South Africa), Proteaceae (Clanwilliam sugarbush *Protea glabra*), Anacardiaceae (*Rhus undulata, R. dissecta)* and Euphorbiaceae (*Euphorbia mauretanica*). As we crossed the river, a patch of riverine scrub included Wild olive (*Olea europaea* ssp. *africana*) and the native willow *Salix hirsute*. Of relevance to the Australians in the party, we observed Wild almond *Brabejum stellatifolium*, the only member of the sub-family Grevilloideae of the Proteaceae to occur in South Africa, a sub-family which is common in and well-represented in Australia; Lance-leaved myrtle, *Metrosideros angustifolia*, the sole African member of a genus linking the southern continents, and *Acacia saligna*. *A. saligna,* an introduction from Australia which poses a threat to native vegetation, is common and a fungus, *Uromycladium*, that causes the development of rusty brown galls, has been imported from Australia to control the trees. Most of the shrubs and herbs we saw on the walk are found only in this area of the Cape. This makes the occurrence of Sand Olive, *Dodonaea angustifolia,* of interest, as *Dodonaea* is native to Africa, California, parts of Asia, Hawaii, New Zealand and Australia, which raises interesting questions as to how all these distant places were colonized by *Dodonaea.* The keen-eyed among us also saw a group of hoofed animals, but I was too busy looking at the plants to focus on them.

A walk to see Fynbos vegetation was planned for the afternoon. Dutch settlers originally referred to the predominant vegetation of the southwestern Cape as *fijn-bosch*, probably related to the small or leathery leafed shrubs adapted to survive dry summers and recurrent natural fires, with intervals between fires varying from two to 60 years. Fires are thought to be one of the major factors influencing the high species richness in the Cape, related to burn season, intensity, extent and interval. Other factors, including the rugged landscape, variable and complex rainfall patterns and diverse soils poor in nutrients, combine to produce a mosaic of different habitats.

Fynbos is dominated by Restionaceae, Ericaceae and Proteaceae, three families that are well represented in the Cape but poorly represented throughout the rest of the world. Restionaceae, which characteristically occurs on sandy or peaty soils low in nutrients, often in seasonally wet sites, has a world-wide distribution of 40 genera and 460 species, of which all except one are confined to the Southern Hemisphere, with main centres of diversity being South Africa (30 genera with more than 250 species) and South-West Australia. Australia has 20 genera, with c.140 species occurring in all states. Ericaceae contains more than 650 *Erica* species, almost all of which are confined to Fynbos. The family Epacridaceae occupies a similar environment in Australia, with 29 genera, c.355 species, occurring in all states. Proteaceae is essentially a Southern Hemisphere family, with Australia and Southern Africa being its centres of greatest diversity. A number of the Proteaceae we saw in the Fynbos, *Protea*, *Leucospermum* and *Leucodendron*, for example, are much prized horticultural plants in Australia.

Due to constraints of time and distance, it was not possible to visit areas of Karoo, so we went to Niewoudtville to visit the Vanrhynsdorp succulent garden and nursery. We were given a talk about the characteristics of the Karoo vegetation and then a tour of the nursery in order to illustrate the characteristics and variety of succulents occurring in Karoo. The term Karoo comes from the Khoekhoe word 'garo', meaning 'land of thirst'. The Karoo vegetation is recognized as one of the world's 25 biodiversity 'hotspots' and is the world's only entirely arid hotspot, carrying the richest arid flora in the world with approximately 5,000 plant species, of which 40% are endemic. Families that are particularly rich in endemics include Amaryllidaceae, Asclepiadaceae, Asteraceae, Crassulaceae, Eriospermaceae, Geraniaceae, Iridaceae, Liliaceae, Euphorbiaceae, Aizoaceae and Zygophyllaceae. Like the Cape Floristic region, the Succulent Karoo is also a largely winter rainfall region, although the average in the Karoo is only 20–50mm per annum.

The nursery had an enormous range of succulents from most of the families mentioned, with sizes ranging from small, well-camouflaged stone plants to succulent 'trees' (such as *Aloe*, which reaches one or two metres in height). The succulents have a range of survival mechanisms, including resurrection plants, ephemerals, small leathery leaves with sunken stomata, retaining seeds tightly in dried flowerheads throughout one or more summers until good rains fall and provide conditions suitable for germination and completion of the life cycle, geophytes with subterranean succulent tubers or bulbs, and stem succulents with thick barrel shaped stems with small scalelike leaves that are shed — the green stem serving for water storage and photosynthesis. Most endemic succulents in South Africa are leaf succulents that vary in shape, size and orientation. Most animal species in these dry regions are dependent on plants for food and moisture, and plants are protected from animal depredation by a number of strategies, including mechanical defence (in the form of spines or prickles), chemical defence or camouflage. The visit completely changed my view of succulents, as the range of size (from dwarf to 1–2m), forms and adaptations, the beauty of the plants and their flowers, and diversity of families represented was truly incredible for an Australian — Australia being a country with dry conditions prevailing over large areas and hence very few succulents.

We set out for Cape Town after a truly inspiring and memorable visit to some of the varied vegetation communities of South Africa. The field trip has led to a wish to revisit these areas, visit new ones and further investigate the South African and Australian floras and their differences and similarities.

Any errors and mistakes are entirely mine. The information about the field trip draws heavily on information gleaned during the trip, field data provided by Jasper, and the following:

Hendey Q.B. (1991) *Langebaanweg, A record of past life*. The Rustica Press.

Slingsby P. (2000) *Rock Art of the Western Cape. Book 1: The Seville Trail and Travellers' Rest.* The FontMaker, Zandvlei 7945.

van Jaarsveld, E., van Wyk, B-E., Smith, G., and Bodley, E., (2000) *Succulents of South Africa.* Tien Wah Press, Singapore.

Images from the Southern Connections coastal tour, 24–28 January, 2004

Barbara Wagstaff

School of Geography and Environmental Science,
Monash University, Victoria 3800, Australia

Forest near Knysna. The high rainfall at the Knysna Forest meant that it is the soil that controls the contrast between the forest and fynbos, with a very sharp division between the two. Oeteniqua yellowwood and real yellowwood (*Podocarus falcatus* and *Podocarpus latifolius*), stinkwood (*Ocotea bullata*) and ironwood (*Olea capensis*) dominate the canopy, with ferns, particularly *Blechnum* sp., forming the ground cover. The massive trees are still logged, although the forester assured us that it was done with minimum damage to the forest. Trees are selected on the basis of their senility. After felling, the tree is dragged out by horse. As the timber is only used to produce high quality furniture, the amount removed is minimal. When questioned as to the need for the older trees to provide habitat for wildlife, we were assured that, unlike Australia, this was not necessary. A walk along the track through the forest involved us in encounters with 10cm long millipedes, dung beetles, frogs and one very small snake, but no elephants. The Knysna Forest elephants were destroyed by hunting and the taking of specimens for scientific research, and there are probably none left. I vainly began pulling out every Acacia seedling that I saw along the side of the track, but gave up as it would have been all I did.

Fire ecologist David Bowman touches an elephant at the Knysna Elephant Park. Note the ever-present *Eucalyptus* trees in the upper right corner of the photograph. Re-introduction of the elephants to the forest is not practical, as the government would have to reimburse the farmers for any damage they caused in the surrounding cultivated areas. The elephants in the Knysna Elephant Park are orphans resulting from the culling in Kruger National Park. They are reared by their carers and are hence reasonably safe for tourists to touch (Figure 2). This was an experience that I must admit was amazing — all that unexpected bristly hair on the skin. However, it was also very sad to see these elephants reduced to such a situation

Current activities of the Centre for Palynology and Palaeoecology, School of Geography and Environmental Science, Monash University

Peter Kershaw

Current programmes include reconstruction of the vegetation and environments of the northern Australia/Indonesia region (largely from marine core evidence), reconstruction of Quaternary environments on the basaltic western plains of Victoria and the Atherton Tableland, the relationship between sea level and human occupation in northeastern Australia, vegetation variation in forests and at high altitudes within the Southeastern Highlands, and the history of river catchments through analysis of billabong sediments.

Marine records, produced by Dr Sander van der Kaars, extending through the last 100,000 to 500,000 years within the Maritime Continent region are revealing marked changes in the distribution and composition of rainforest, savanna and arid vegetation in relation to global ice volume and monsoon forcing, and an overall trend to more open canopied vegetation and alteration in fire activity as a result of drier climatic conditions. A similar vegetation trend is evident in northeastern Australia, but ENSO variability rather than a waning monsoon appears to be the critical influence here. There is also evidence, from a combination of altered fire regimes and sustained vegetation change, for major human impact regionally, dating from about 45,000 years BP and possibly from about 130,000 years BP. Decoupling the relative importance of people and climate on vegetation change and elucidation of detailed patterns of ENSO variation from the site of Lynch's Crater are major aims of the PhD project of Sue Rule, supported by an ARC Discovery grant recently awarded to Raphael Wust of JCU and Peter Kershaw. Recoring Lynch's Crater with a National Geographic grant to Chris Turney and Peter Kershaw and with the ANU drilling rig was attempted last year. A second attempt, with additional support from JCU, will be attempted this year. It is hoped that the weather will be less inclement. Palynological study is continuing on Kalimantan peatlands with a Holocene record being produced last year by Professor Wang Weiming, a visitor from the Institute of Geology and Palaeontology, Academia Sinica, Nanjing. The core was collected by Raphael Wust, primarily for geochemical study. This research, including the ongoing palynological studies of research student Asha Thamotherampillai, is contributing to the Kalimantan Tropical Peat Swamp Forest Research Project, headed by Jack Rieley, University of Nottingham.

Honorary Fellow Bob Morley is undertaking biostratigraphic work for Unocal Indonesia Inc. in shelf and slope settings offshore Mahakam Delta and placing this into a firm chronostratigraphic and sequence stratigraphic framework. Much of the palynological component is being undertaken by Sander van der Kaars and is contributing to the understanding of climate and vegetation change of the more general Maritime Continent region in the late Quaternary. Patrick Moss, currently at the University of Wisconsin, has maintained close involvement with the Centre, including recent pollen analysis of Lynch's Crater. He has also extended the ODP 820 record, the subject of his PhD, from 250,000 to 500,000 years BP in order to test the hypothesis that sustained vegetation changes in northeastern Australia were the direct result of alterations in oceanic conditions within the mid-Brunhes period.

Large chunks of the Quaternary vegetation history of the Western Plains of Victoria are being revealed from the study of old volcanic craters. Dr Barbara Wagstaff has recently completed analysis of two overlapping pollen sequences that extend from about 1.3 to 0.7 million years ago and show marked vegetation responses to changing orbital forcing around the early- to mid-Pleistocene boundary. These changes include more marked vegetation variation with the development of existing, distinctive cool temperate rainforest, the possible loss from the region of araucarian forest remnants, and a decline in *Callitris* dominated communities. An older sequence, dating to the base of the Quaternary, being analysed by PhD student Kale Sniderman shows remarkable cyclical alternation between rainforest and sclerophyll vegetation. The rainforest was diverse and shows very late survival of almost all taxa that characterised the mid to late Tertiary period in southeastern Australia. In combination with Barbara's records, it appears that precession-dominated southern hemisphere solar insolation variation, rather than forcing from the northern hemisphere ice sheets, was the dominant influence on Quaternary climate until about 1 million years ago.

In the more recent past, PhD student Rochelle Johnston is finalising her high resolution palynological study on the Pleistocene/Holocene transition at Tower Hill, designed to examine vegetation responses to rapid climate change. This site, together with similar high resolution and well dated transition studies of Lynch's Crater and Rawa Danau in Java, are being compared, primarily by Chris Turney, to determine the regional nature of transition events and their degree of synchroneity with the well-established pattern that includes the Younger Dryas in the northern hemisphere. A high resolution pollen record from Lake Surprise in far western Victoria is being prepared by PhD student Chris White, with support from an ARC Linkage grant to Peter Kershaw and archaeologist Heather Builth. The major aim of this project is to provide a regional environmental record for assessment of Aboriginal occupation and impact, and to shed light on the timing of proposed intensification of occupation associated with the development of eel aquiculture. The existing record covers the last 18,000 years. Recent coring, with the assistance of Jim Neale, has extended sediment recovery from an original 13m to 20m: the base of the lake sediments. A link between the sub-humid plains and semi-arid environments, especially Lake Mungo, is being provided by Ellyn Cook's PhD study of the history of the lunette lake system of Bolac. Ellen is complementing pollen with analysis of other regularly encountered but seldom acknowledged palynomorphs in pollen samples.

Volcanic Province related projects, utilising constructed palaeoecological records, include an assessment of the potential for tephrochronological correlation of records from both northeastern and southeastern Australia by PhD student Sarah Davies, working from Queen's University Belfast, and the production of a dust record from Lake Surprise by honours student Fiona Bertuck.

Archaeological applications are prominent in coastal studies within northeastern Australia, where Dr John Grindrod is examining swamp histories within the Whitsunday Islands and on Cape York Peninsula. PhD student Cassie Rowe is undertaking a vegetation and fire history of Torres Strait Islands in order to contribute to a major archaeological study of these islands by members of the School's fledgling Indigenous Archaeology Programme. She is supported by an ARC Discovery grant. Further from the coast, research student Nic Dolby continues to address Aboriginal wood use and vegetation change from charcoal identified in the archaeological site of Ngarrabullgan on Cape York, excavated by Dr Bruno David.

Caledonia Fen, in the Snowy Ranges, provides a major focus of research in the southeastern highlands. Dr Merna McKenzie celebrated her 80th year by completing a high resolution pollen record that extends through the whole of the last glacial cycle. This record provides some interesting insights into 'normal' conditions in the highlands that are very different to those of today. Details of the stability of this environment are being provided by PhD student Jonathan Brown through physical analysis, mineral magnetism and OSL dating of catchment and lake sediments. Jonathon has benefited greatly from a stint in the Mineral Magnetism Laboratory of Barbara Maher at the University of Lancaster, and from association with Bert Roberts and the Melbourne University OSL lab. In the mountain ash forests, PhD student Alex McLeod is modelling vegetation-fire relationships in association with Jim Clark of Duke University, with a historical perspective provided by the identification and dating of soil charcoal. PhD student Cecilia Elwood is attempting to reconstruct the vegetation and climate history of the Tasmanian highlands at a scale comparable with ecological monitoring through the dendrochronology of *Athrotaxis* combined with high resolution pollen and charcoal analysis of lake sediments.

A number of existing sites of palaeoecological investigation have been utilised for palaeoclimatic reconstruction using fossil beetle assemblages. PhD student Nick Porch has applied an extensive data base that he built on present-day ranges of Australian beetles to the refinement of past temperatures that have been difficult to derive from other proxy data.

Palaeolimnological studies have been concentrated on the study of diatoms in billabong sediments in order to document changes in stream water quality and variability through the last few thousand years. The Murray Basin has been a central focus, although expertise has largely moved to the Department of Geography and Environmental Studies at the University of Adelaide. However, the Centre is still involved in providing broader catchment information from pollen data. In a separate palaeolimnological study of the Yarra River, PhD student Paul Leahy has documented the pre-contact state of the river, as well as the degree and causes of change within this system subsequent to the arrival of Europeans, through analysis of three billabongs. The results suggest that the presumed natural state of the river needs to be reconsidered. Hopefully this information will be revealed if the acquisition of a job with the Victorian Environmental Protection Authority does not prevent him completing his thesis in the near future. Nerida Bleakley has completed her thesis on a sediment-based study of the diatoms and chemistry of a Fjord system in Antarctica, which provides some insights into the complexity of a lake-marine-ice system as well as a detailed climate record for the last 4,000 years. The opportunity was taken to involve French/ Canadian diatomist Aline Philibert, who is visiting the University of Adelaide, in the Lake Surprise project. She has produced an excellent continuous record of the last 18,000 years.

The Centre has benefited greatly from continued collaboration with ex-members, especially Simon Haberle and John Tibby, who continue to play a very active role in student supervision. We are also grateful to Meredith Orr, Chris Turney, Bruno David, Patrick De Deckker and Andrew McMinn for their important supervisory contributions.

Publications

Genever, M., Grindrod, J. F. and Barker, B. 2003. Holocene palynology of Whitehaven Swamp, Whitsunday Island, Queensland, and implications for the regional archaeological record. *Palaeogeography, Palaeoclimatology, Palaeoecology* 201: 141–156.

Haberle, S. 2003. Late Quaternary vegetation dynamics and human impact on Alexander Selkirk Island, Chile. *Journal of Biogeography* 30: 239–255.

Hesse, P. P., Magee, J. W. and van der Kaars, S. 2004. Late Quaternary climates of the Australian arid zone: a review. *Quaternary International* 118–119: 87–102.

Hope, G. S., Kershaw, A. P., van der Kaars, S., Sun, X., Liew, P-M., Heusser, L. E., Takahara, H., McGlone, M., Myoshi, N. and Moss, P. T. 2004. History of vegetation and habitat change in the Austral–Asian region. *Quaternary International* 118–119: 103–126.

Kershaw, A. P., D'Costa, D. M., Tibby, J., Wagstaff, B. E. and Heijnis, H. (in press). The last million years around Lake Keilambete, western Victoria. *Proceedings, Royal Society of Victoria*.

Kershaw, A. P., Moss, P. T. and van der Kaars, S. 2003. Causes and consequences of long-term climatic variability on the Australian continent. *Freshwater Biology* 48: 1274–1283.

Kershaw, A. P., Moss, P. T. and Wild, R. (in press) Patterns and causes of vegetation change in the Australian wet tropics region over the last 10 million years. In C. Moritz and E. Bermingham (eds.) *Tropical Rainforests: Past and Future*. Chicago University Press.

Kershaw, A. P., van der Kaars, S. and Moss, P. T. 2003. Late Quaternary Milankovitch-scale climate change and variability and its impact on monsoonal Australia. *Marine Geology* 201: 81–95.

Morley, R. J., 2003. Interplate dispersal paths for megathermal angiosperms. *Perspectives in Plant Ecology, Evolution and Systematics* 6: 5–20.

Morley, R.J. 2003. Missing fossils, molecular clocks, and the origin of the Melastomataceae. *American journal of Botany* 90: 1638–1644.

Sherwood, J., Oyston, B. and Kershaw, A.P. (in press). The age of Tower Hill volcano, southwest Victoria, Australia, *Proceedings, Royal Society of Victoria*

Sniderman, J. M. K., O'Sullivan, P. B., Hollis, J. and Kershaw, A. P. (in press). Late Pliocene vegetation and climate change in the Western Uplands of Victoria, Australia. *Proceedings, Royal Society of Victoria*.

Tibby, J. 2003. Explaining lake and catchment change using sediment derived and written histories: an Australian perspective. *The Science of the Total Environment* 310: 61–71.

Tibby, J. (in press). Development of a diatom-based model for inferring total phosphorus in south-eastern Australian storages. *Journal of Palaeolimnology*.

Tibby, J., Reid, M. A., Fluin, J., Hart, B. T. and Kershaw, A.P. 2003. Assessing long-term pH change in an Australian river catchment using monitoring and palaeolimnological data. *Environmental Science and Technology* 37: 3250–3255.

Turney, C. S. M., Kershaw, A. P., Clemens, S., Branch, N., Moss, P. T. and Fifield, L. K. 2004. Millennial and orbital variations in El Niño/Southern Oscillation and high latitude climate in the last glacial period. *Nature* 428: 306–310

Van der Kaars, S. and De Deckker, P. 2003. Pollen distribution in marine surface sediments offshore Western Australia. *Review of Palaeobotany and Palynology* 124: 113–124.

OTHER RECENT PUBLICATIONS

Joyce, E. B. 2003. Landscape and geological heritage: a Baragwanath seminar sponsored by GSA heritage workers. *The Australian Geologist*, No. 126, March 30, 2003, pp.11–13 + front cover.

Joyce, E. B., Webb, J. A., Dahlhaus, P. G., Grimes, K. G., Hill, S. M., Kotsonis, A., Martin, J., Mitchell, M. M., Neilson, J. L., Orr, M. L., Peterson, J. A., Rosengren, N. J., Rowan, J. N., Rowe, R. K., Sargeant, I., Stone, T., Smith, B. K., and White, S. (with material by the late J. J. Jenkin) 2003. Geomorphology, the evolution of Victorian landscapes. Chapter 18, In Birch W. D. (ed.) *Geology of Victoria*, pp. 533-561. Geological Society of Australia Special Publication No. **23**. Geological Society of Australia (Victoria Division).

Joyce, E. B. 2004. The geomorphology of Victoria: a new view of the landscape. 11th ANZGG Meeting, Mt Buffalo, Australia, February 15–20, 2004. Conference Program, Abstracts and Participants, ANZGG Occasional Paper No. 3, p.38.

Taylor, D.; Lu, X.X.; Adger, W.N.; Lowe, D.J.; de Lange, W.P.; Newnham, R.M.; Dodson, J.R. 2004. Interactions of natural hazards and society in Austral-Asia: evidence in past and recent records. *Quaternary International*, 118–119: 181–203.

Turney, C.S.M.; Lowe, J.J.; Davies, S.M.; Hall, V.A.; Lowe, D.J.; Wastegård, S.; Hoek, W.Z.; Alloway, B.V. 2004. Tephrochronology of Last Termination sequences in Europe: a protocol for improved analytical precision and robust correlation procedures (a joint SCOTAVINTIMATE proposal). *Journal of Quaternary Science*, 19: 111-120.

Haworth, R.J., Baker, R.G.V, Flood, P.G. 2004. A 6000 year old dugong from Botany Bay: inferences about changes in Sydney's climate, sea levels, and waterways. *Australian Geographical Studies*, 42: 46-59.

Gale, S.J. 2003. Making the European landscape: early contact environmental impact in Australia. In Geography's New Frontiers. G*eographical Society of New South Wales Conference Papers*, 17: 7-16.

THESIS ABSTRACT

Coral Reconstructions of mid-Holocene Ocean-Atmosphere Variability in the Western Pacific Warm Pool

Helen V. McGregor*

The Australian National University, August 2003

This thesis explores Holocene climate conditions in the western Pacific warm pool (WPWP) using geochemical tracers in fossil corals from the north coast of Papua New Guinea (PNG). The WPWP, with an annual average sea surface temperature (SST) exceeding 28°C, is not only a major heat source driving equator-to-pole atmospheric circulation, but is a fundamental component of the El Niño-Southern Oscillation (ENSO) system. Ocean-atmosphere interactions in the warm pool are instrumental in triggering ENSO warm events (El Niño events). Given the often severe ENSO-related climate impacts around the globe, the mid-Holocene has emerged as a key period for investigating this system due to subtle differences in the distribution of solar insolation, relative to that of today. An understanding of how the WPWP climate responded to this altered background state can give us clues as to how ENSO may change under other altered background climate conditions, such as that brought about by atmospheric CO_2 levels during the 21st century. To address this issue, fossil and modern *Porites* corals were sampled from uplifted and living reefs on Muschu and Koil Islands, PNG, to reconstruct the mid-Holocene climate in the WPWP. Skeletal Sr/Ca and oxygen isotope ratios ($\delta^{18}O$) were measured in seven fossil corals with ages between 7.6-5.4 ka (x1000 calendar years ago), one 2 ka coral, and three modern corals. The results were used to calculate SST and the oxygen isotope residual ($\Delta\delta^{18}O$), the two main proxies for warm pool climate used in this study.

Three modern corals, two from Muschu Island and one from Koil Island, were analysed for Sr/Ca and $\delta^{18}O$ to establish the methodologies to apply to the fossil corals. Sr/Ca and $\delta^{18}O$ analyses on annually-resolved samples from the three modern corals were used to assess the level of reproducibility amongst coral records for this region. The spread of $\delta^{18}O$ data about the mean value for the three corals was 0.04‰, and for the Sr/Ca data was 0.00001. When converted to SST, the spread for the Sr/Ca data is equivalent to ± 0.7C. Seasonally resolved Sr/Ca data from a modern Muschu Island coral were found to track SST changes observed in the instrumental records. This was combined with other modern coral Sr/Ca data from the PNG region and used to develop a calibration equation to convert Sr/Ca to SST. The Sr/Ca-SST calibration equation is $Sr/Ca_{atomic} x10^3 = 11.0 - 0.075 \times SST$. The modern Muschu coral was also analysed for $\delta^{18}O$ at seasonal resolution. The seasonal $\delta^{18}O$ and Sr/Ca data from the Muschu coral were then used to calculate $\Delta\delta^{18}O$, by removing the SST component from the $\delta^{18}O$ results. $\Delta\delta^{18}O$ was converted to sea surface salinity (SSS) using the following seawater $\delta^{18}O$-SSS relationship developed from tandem measurements on water samples from the north coast of PNG: $\delta^{18}O_w = -8.7 + 0.26 \times SSS$. The modern corals record seasonal, inter-annual and decadal scale climate variability. The seasonally resolved Sr/Ca-SST data showed one annual minimum in January, probably due to northwesterly wind driven coastal upwelling. A $\Delta\delta^{18}O$ maximum in January, also likely reflects upwelling, as well as the annual rainfall minimum. $\Delta\delta^{18}O$ was at a minimum when rainfall was highest from May-August and southeasterly winds prevail. Both coral Sr/Ca-SST and $\Delta\delta^{18}O$ show relatively cool and more saline conditions (reduced rainfall) respectively, during ENSO warm events. The annually-resolved Sr/Ca and $\delta^{18}O$ records

*Current address: Universität Bremen, FB5 Geowissenschaften, Postfach 330440, D-28334 Bremen, Germany, mcgregor@uni-bremen.de

for the three modern corals were averaged and used as the baseline for assessing relative changes in mean climate observed in the fossil coral climate records.

Climate reconstructions derived from the geochemistry of fossil corals can be corrupted by diagenetic alteration of coralline skeletal aragonite. To understand the impact of vadose-zone diagenesis on coral climate proxies, two of the mid-Holocene *Porites* corals were analysed for Sr/Ca, $\delta^{18}O$, and $\delta^{13}C$ along transects from 100% aragonite to 100% calcite. Thin-section analysis showed a characteristic vadose zone diagenetic sequence, beginning with leaching of primary aragonite and fine calcite overgrowths, transitional to calcite void filling and neomorphic, fabric selective replacement of the coral skeleton. Average Sr/Ca and $\delta^{18}O$ values for calcite were lower than those for coral aragonite, decreasing from 0.0088 to 0.0021 and –5.2 to –8.1‰, respectively. Diagenesis has a greater impact on reconstructions of SST from Sr/Ca, relative to $\delta^{18}O$; the calcite compositions reported here convert to SST anomalies of 115C and 14C, respectively. Thus, based on the calcite Sr/Ca compositions analysed in this study and in the literature, the sensitivity of coral Sr/Ca-SST to vadose-zone calcite diagenesis is 1.1–1.5°C per percent calcite. In contrast, the rate of change in coral $\delta^{18}O$ SST is relatively small (–0.2 to 0.2°C per percent calcite). The results indicate that large shifts in $\delta^{18}O$, reported for mid-Holocene and Last Interglacial corals with warmer than present Sr/Ca-SSTs, cannot be caused by diagenesis. X-ray diffraction and petrographic analysis of fossil coral skeletons used for climate reconstruction in this thesis revealed no significant diagenesis.

Fossil corals records of Sr/Ca and $\delta^{18}O$ were used to infer mean SST, $\Delta\delta^{18}O$ and SSS conditions in the WPWP during the mid-Holocene. The U-Th dated fossil corals show that from 7.6 to 6.1 ka SSTs were on average ~0.9C cooler than at present, and $\Delta\delta^{18}O$ converted to SSS suggests conditions were ~1.5 psu more saline than today. Taken together with other tropical Pacific SST proxy records, the overall SST structure is evocative of the modern-day ENSO cool phase (La Niña). If a mean La Niña state was operating during this time, then the easterly trade winds were likely to have been stronger, thus increasing evaporation relative to precipitation and raising the SSS of the warm pool. An abrupt shift, particularly in the $\Delta\delta^{18}O$, was identified between 6.1 and 5.4 ka. This shift, indicating a decrease in SSS of ~1.5 psu, may represent the establishment of a modern-like WPWP. The timing of the abrupt shift is similar to abrupt shifts identified in proxy climate records from the Indian sub-continent, Indian Ocean and tropical east Atlantic. The timing is also similar to an enhanced millennial-scale climate oscillation in drift-ice rafting and deepwater production, identified in the North Atlantic. This shift points to the WPWP playing a stronger role than previously thought in global climate change during the Holocene.

Annually-resolved $\delta^{18}O$ data from the seven fossil corals aged from 7.6–5.4 ka showed an El Niño recurrence interval of nine years, compared to seven years for a $\delta^{18}O$ coral record spanning 1911–1997AD. This suggests that El Niño was slightly suppressed during this time as indicated by models, though not to the same extent as suggested by South American lake sediment records. Four fossil corals dating to 7.3 ka, 6.1 ka, 5.4 ka and 2 ka were analysed at bimonthly resolution for Sr/Ca and $\delta^{18}O$ to investigate changes in the seasonal cycle of SST and $\Delta\delta^{18}O$, and changes in the El Niño signal. The results for the period 7.3–6.1 ka suggest locally increased rainfall during the middle of the year, implying strengthened southeasterly winds, consistent with an enhanced La Niña state during this time. By 5.4 ka, mid-year $\Delta\delta^{18}O$ were at a maximum locally, implying that the southeast trade winds weakened. This is consistent with overall fresher mean surface ocean conditions and suggests that the modern SST and SSS structure of the WPWP may have been established at this time. Analysis of $\Delta\delta^{18}O$ for the El Niño years observed in the 7.3 ka, 6.1 ka and 5.4 ka coral records showed that El Niño events at these times peaked during the middle of the year. This peak in mid-Holocene El Niño events is 4–6 months earlier than the peak in El Niño today (usually at the end of the year). A 7-year protracted El Niño was identified in the 2 ka coral $\delta^{18}O$ records, consistent with increased El Niño frequency and intensity found in both modelling and proxy studies. High-resolution Sr/Ca and $\delta^{18}O$ analysis of one year of the 7-year El Niño event showed that it peaked at the same time as today. The high-resolution results imply that small changes in background conditions — such as orbital parameters and/or the strength of the tropical monsoons — as proposed by modelling studies, can influence the development of ENSO events. Therefore, it is not possible to rule-out the potential for changes in background conditions, such as the current increase in CO_2 levels in the atmosphere from the burning of fossil fuels, to cause large changes in the ENSO.

Evolutionary Legacy of the Ice Ages

Reviewed by K. Sniderman

The evolutionary legacy of the Ice Ages: Papers of a Discussion Meeting organized and edited by K. J. Willis, K.D. Bennett and D. Walker. A special issue (Volume 359, no. 1442) of *Philosophical Transactions of the Royal Society*. £45/US$70 from The Royal Society, (TB 1442) PO Box 20, Wetherby, West Yorkshire LS23 7EB, UK.

The stated purpose of the Royal Society discussion meeting which formed the basis for this special issue was 'to examine current fossil and molecular research for the degree to which Ice Ages may have contributed to the evolution of organisms', and, more specifically, to 'examine the mechanisms and rates of organismal responses to a known critical period of climate change in the Earth's history' (Willis et al., p. 157). These issues are addressed in 13 contributed papers, at both macroevolutionary (speciation) and phylogeographic (infraspecific) genetic scales, in attempts to answer several questions: Has speciation occurred within the Quaternary and, if so, has it occurred at rates exceeding those typical of earlier intervals of Earth history? What is the relationship between phylogeographic patterns (the geographic distribution of infraspecific genetic variation), orbitally forced glacial cycles, and speciation?

Contributing authors address these questions at a variety of temporal scales, ranging from the Late Neogene to the Holocene, through analysis of a range of organisms including modern humans and hominids, mammals, birds, insects and vascular plants. With this diversity in mind, it may be difficult to make generalisations across taxonomic groups within which the evolutionary response to the Quaternary has ranged from abundant speciation (in mammals) to apparently near universal stasis (in beetles). We are clearly still a long way off providing general explanations for this variability, given, among other factors, the counter-intuitive lack of a correlation between speciation rate and generation time. The uncertainties introduced by this variability lead some authors to question whether at least some of the differences in observed evolutionary responses simply reflect interdisciplinary methodological artefacts (A. M. Lister) or, given that most of the data presented here is derived from northern temperate latitudes, our relative ignorance of tropical neo- and palaeodiversity (G. R. Coope). Despite these uncertainties, Keith Bennett concludes in his summary paper that speciation during the Quaternary has, in general, been minimal.

To interpret this conclusion, Bennett focuses on Milankovitch cycles as potential forcing agents of evolutionary change. He proposes that population level genetic divergences accumulated within one phase (traditionally, an interglacial) of an orbitally forced climate cycle are likely to be eliminated during the subsequent opposite phase (traditionally a glacial, though J. W. Kadereit et al. argue — in the context of inferred Pleistocene speciation of European alpine herbs — that glacial phases may have been as important for speciation as interglacials). Hence microevolutionary processes at the ecological scale (natural selection, Stephen Jay Gould's 'first tier') are undone at orbital scale (Bennett's 'second tier') and evolutionary stasis is the norm. As a theoretical framework explaining why we should *not* expect speciation as a consequence of orbitally forced cyclic climate fluctuations, there is little in this collection to contradict Bennett's thesis. For example, many phylogeographic patterns (G. M Hewitt and M. Lascoux et al.) appear to result primarily from changing distributions only within the most recent glacial cycle, hence they are presumably evolutionarily trivial with little significance for speciation (but see the contribution by G. E. McKinnon et al., which suggests that at least some *Eucalyptus* species are merely stabilised hybrid forms, drawn from the regional eucalypt gene pool and specific to the current interglacial phase; this appears to imply that some eucalypt 'species' are either created anew, or perhaps resurrected, with each glacial cycle).

Conversely, Lascoux et al. also present evidence (from western North American *Pinus ponderosa*) of between-population genetic divergences that appear to be older than the most recent cycle, suggesting that the evolutionary clock is not always reset to zero by Milankovitch cycles. It follows that trends of divergence such as that seen in *P. ponderosa* occur despite, rather than because of glacial cycles and perhaps represent cases of incipient speciation that have little or no evident causal relationship to Milankovitch cyclicity. However, Bennett effectively sweeps the general question of Quaternary speciation under the carpet of a stasis-reinforcing Milankovitch cyclicity, by implying that, because speciation does not occur at Milankovitch time scales, it is unimportant within the Quaternary. As a fallback position, it is acknowledged that limited Quaternary speciation has occurred, but at rates indistinguishable from — in some cases faster, in other cases slower than — those inferred for other periods, hence speciation *rate* has not been a distinctive feature of the Quaternary.

These are not surprising conclusions, partly because this is familiar ground (Bennett, 1990, 1997), but they beg the question of the extent that the modern biota represents an evolutionary response more generally to the onset and continued development of 'Quaternary-like' conditions. The decoupling of speciation and Milankovitch forcing is reinforced by A. M. Lister's overview of the evidence for macroevolutionary responses by mammals to peculiarly Quaternary environments, showing that the many undeniable Quaternary mammal originations and extinctions appear to have little relationship to individual orbital cycles. Yet Lister is alone in emphasising Quaternary neospecies (e.g., mammoth, reindeer) as ecologically distinctive evolutionary *products* (though C. Gamble et al.'s exploration of fundamental differences in social construction between Neanderthals and moderns similarly focuses on the distinctive characteristics of a successful neospecies). Perhaps this emphasis will receive more attention if the hypothesis upon which this Royal Society discussion was based — that individual glacial cycles might have driven speciation — deserves to be abandoned.

Alternatively, there is relatively little attention paid to the possibility that speciation occurs in response to major shifts in climatic regime — such as that which marked the onset of the Quaternary — or associated with the shift in frequency and amplitude of orbital cyclicity around the Early/Middle Quaternary transition. This theme is taken up only by E. S. Vrba and D. DeGusta, who argue that late Neogene African mammal speciation events were clustered within turnover pulses coordinated by large scale climatic shifts. This perspective suggests that much of the evolutionary action with respect to the Quaternary biota may have occurred near the beginning of the period and, while stasis may dominate the middle and late Quaternary, this doesn't imply that the period has been an uneventful time evolutionarily.

There is further evidence, beyond that presented in this collection, for speciation both immediately before, but also well within the Quaternary. Phylogenetic evidence based on a range of molecular markers indicates the radiation of several modern plant taxa, beginning, in many cases, around the latest Miocene/Early Pliocene, but often extending well into the Pleistocene. For example, the species-rich Moraeae (Iridaceae) (Goldblatt et al., 2002), Phylica (Rhamnaceae)(Richardson et al., 2001b), Ruschioideae (Aizoaceae) (Klak et al., 2004), Plantago (Plantaginaceae) (Rønsted et al., 2002) and Inga (Mimosaceae) (Richardson et al., 2001a) appear to first diverge near and presumably in response to this distinct step within ongoing global late Cenozoic refrigeration. While some of the constituent species appear to be nearly as old as their genera, the larger proportion of species exhibit very limited interspecific genetic distances and are thus inferred to represent Late Pliocene-Early Pleistocene radiations. Regionally, Australasian and Pacific representatives of several herbaceous genera — including *Lepidium* (Mummenhoff et al., 2001) and *Cardamine* (Bleeker et al., 2002) (Brassicaceae), *Microseris* (Asteraceae) (Vijverberg et al., 1999), and *Plantago*, and, of the arboreal genera *Sophora* sect., *Edwardsia* (Fabaceae) (Mitchell and Heenan, 2002) and *Metrosideros* (Myrtaceae)(Wright et al., 2001) — exhibit very limited (in some cases zero) sequence divergences consistent with radiations ranging from 2 to as little as 0.5 million years ago. While many of the taxa mentioned are confined to the southern hemisphere, some, such as *Lepidium* and *Plantago*, include equally young Eurasian species groups, so it is not clear that such recent evolution is solely an austral phenomenon. All of these taxa — rapidly maturing shrubs, herbs and trees of ruderal habitats — seem to share common ecological traits often considered to have been favoured by Quaternary aridity, cold, strong seasonality and general climatic variability. Their age-calibrated phylogenies suggest a pattern of radiation in response to the development and progressive expansion of more or less novel habitats to which the incumbent, 'Tertiary' biota was perhaps relatively poorly adapted. While providing no support for the importance of any individual glacial cycle, let alone the most recent one, this evidence does imply that, for some ecological groups at least, the Quaternary has been a time of continuing adaptation within lineages that mostly arose earlier in response to developing Late Cenozoic environments.

I am not convinced that speciation has been unimportant in the Quaternary — in the sense of its contribution to the populating of modern ecosystems. It seems possible, however, in contrast with the conclusion of K. J. Willis and K. J. Niklas, that Quaternary glacial cyclicity may not have been operating long enough to see evolutionary results, that much of the evolutionary novelty of the Quaternary was concentrated near and soon after its initiation. This special issue forms an important contribution to the 'continuing … debate on the role of Quaternary environmental change for macroevolution', but, I hope, will not be the last word on the subject.

References cited beyond those included in the special issue:

Bennett, K. D. 1990. Milankovitch cycles and their effects on species in ecological and evolutionary time. *Paleobiology*, 16: 11–21.

Bennett, K. D. 1997. *Evolution and Ecology: The Pace of Life*. Cambridge University Press.

Bleeker, W., Franzke, A., Pollman, K., Brown, A. H. D. and Hurka, H. 2002. Phylogeny and biogeography of southern hemisphere high-mountain *Cardamine* species (Brassicaceae). *Australian Systematic Botany*, 15: 575–581.

Goldblatt, P., Savolainen, V., Porteous, O., Sostaric, I., Powell, M., Reeves, G., Manning, J. C., Barraclough, T. G. and Chase, M. W. 2002. Radiation in the Cape flora and the phylogeny of peacock irises Moraea (Iridaceae) based on four plastid DNA regions. *Molecular Phylogenetics and Evolution*, 25: 341–360.

Klak, C., Reeves, G. and Hedderson, T. 2004. Unmatched tempo of evolution in Southern African semi-desert ice plants. *Nature*, 427: 63–65.

Mitchell, A. D. and Heenan, P. B. 2002. *Sophora* sect. *Edwardsia* (Fabaceae): further evidence from nrDNA sequence data of a recent and rapid readiation around the Southern Oceans. *Botanical Journal of the Linnean Society*, 140: 435–441.

Mummenhoff, K., Bruggemann, H. and Bowman, J. L. 2001. Chloroplast DNA phylogeny and biogeography of *Lepidium* (Brassicaceae). *American Journal of Botany*, 88: 2051–2063.

Richardson, J. E., Penningston, R. T., Pennington, T. D. and Hollingsworth, P. M. 2001a. Rapid diversification of a species-rich genus of neotropical rain forest trees. *Science*, 293: 2242–2245.

Richardson, J. E., Weitz, F. M., Fay, M. F., Cronk, Q. C. B., Linder, H. P., Reeves, G. and Chase, M. W. 2001b. Rapid and recent origin of species richness in the Cape flora of South Africa. *Nature*, 412: 181–183.

Rønsted, N., Chase, M. W., Albach, D. C. and Bello, M.A. 2002. Phylogenetic relationships within *Plantago* (Plantaginaceae): evidence from nuclear ribosomal ITS and plastic *trnL-F* sequence data. *Botanical Journal of the Linnean Society*, 139: 323–338.

Vijverberg, K., Mes, T. H. M. and Bachmann, K. 1999. Chloroplast DNA evidence for the evolution of *Microseris* (Asteraceae) in Australia and New Zealand after long-distance dispersal from western North America. *American Journal of Botany*, 86: 1448–1463.

Wright, S. D., Yong, C. G., Wichmann, S. R., Dawson, J. W. and Gardner, R.C. 2001. Stepping stones to Hawaii: a trans-equatorial dispersal pathway for *Metrosideros* (Myrtaceae) inferred from nrDNA (ITS + ETS). *Journal of Biogeography*, 28: 769–774.

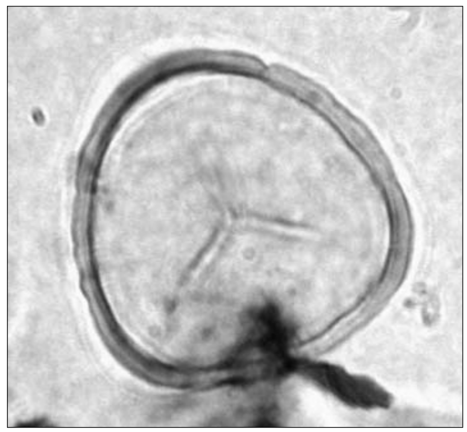
Mystery fossil spore

Angus Tye

Doctoral Candidate
School of Anthropology, Geography and Environment Studies
University of Melbourne
a.tye@pgrad.unimelb.edu.au

I am studying the Holocene vegetation/fire and climate of the giant sand islands of south-east Queensland (Fraser, Moreton, North Stradbroke Islands) and of Cooloola sand mass. I have attached three photos of a spore which I am finding in increasing quantities from 150cm down. The only spore I can find that resembles it is *Sphagnum*. However, my supervisor, Ian Thomas, is sure that no *Sphagnum* would be present, due to the nature of a low altitude coastal inter-dunal depression. So I am hoping for help with identification.

The core that I am looking at is from a small depression at 153.17°E 25.67°S and is situated in a *Eucalyptus*/*Banksia* depression some 7km from the eastern coastline. From very rough calculations, I am assuming its age is 3-4 ky bp (no dating available yet, due to lack of funding).



The description of the grain is:

Triangular with max. length 40µm
Exine ~2.5µm, thickens at corners to 3.5µm
Scar is very clear but arms do not extend to edge

Photos taken at 100×.

Australasian Quaternary Association

Financial Statement for 2003

INCOME AND EXPENSE REPORT (1 January, 2003 to 31 December, 2003)

Uncommitted balance brought forward	$32,484.11	$30,503.55
	2003	**2002**
INCOME		
Business income — Concession	1,095.00	1,240.00
Business income — Full	3,920.00	3,770.00
Business income — Institute	489.10	467.32
Business Income Total	5,504.10	5,477.32
C'wealth Bank Interest	50.57	43.56
Bank Melbourne Interest (12 month)	647.74	524.50
Bank Melbourne Interest (6 month)	82.24	479.59
Bank Interest Total	780.55	1,047.65
Port Fairy Income		195.30
Westport Conference Income	2,010.24	
Quaternary International special issue	100.00	425.00
Misc. Income	10.10	
TOTAL INCOME	8404.99	7,145.27
EXPENSES		
QA expense — printing	3,720.00	1,636.00
QA Expenses (software)	413.60	30.00
Bank Fees	13.00	
GDT	33.20	15.60
Merchant bank fee	230.17	208.18
Transaction Errors	65.00	
Australian Geosciences Council	550.00	550.00
Science Meets Parliament Forum		99.00
Prize — travel	1,000.00	1,500.00
Incorporation cost	33.00	
Postage	785.71	841.48
Committee expenses		284.45
Subscription refunds	60.00	
Westport Travel Subsidies	2,500.00	
Westport Conference Expenses	214.45	
Westport Conference Student Prizes	1350.00	
2004 Conf. Deposit – Doherty's Hotel	4,005.00	
TOTAL EXPENSES	14973.13	5,164.71
INCOME LESS EXPENSES	–6,568.14	1,980.56
Transfer Bank Melbourne — Commonwealth Bank		3,058.28
Assets (31 December 2003)		
Commonwealth Bank account	5,915.97	8,847.50
Bank of Melbourne Term Deposit (6 month)	closed	10,000.00
Bank of Melbourne Term Deposit (12 month)	closed	13,636.61
Commonwealth Fixed Interest Account (6mth)	20,000.00	
TOTAL	**25,915.97**	**32,484.11**

[Income variation on 2002 balance due to conference deposit and increases in publication costs.]

I have examined the records of the Australasian Quaternary Association and I am of the opinion that the above Income and Expense Report gives a true and fair view of the affairs of the Association for the year ended 31 December, 2003.
Marcia Murphy ASA

Expense Report gives a true and fair view of the affairs of the Association for the year ended 31 December, 2002.
Dick Adair

FORTHCOMING CONFERENCE AND MEETINGS

4th International Symposium on Extant and Fossil Charophytes

Robertson, New South Wales, Australia. 25–27 September, 2004 (21–30 September including pre- and post-symposium field trips).

The Symposium is open to all topics dealing with Charophytes: Systematics, phylogeny, palaeolimnology (application to Quaternary studies), management of water bodies, molecular biology, ecology, palaeontology, geochemistry.

Milutin Milankovitch Anniversary Symposium: Paleoclimate and the Earth Climate System

Belgrade, Serbia, 30 August–2 September, 2004

On the occasion of the 125th anniversary of the birth of Milutin Milankovitch, Serbian.

The Academy of Sciences and Arts is organising an international symposium aimed at reviewing the state-of-the-art of climate science as it relates to the work of Milankovitch. The emphasis of the symposium will be paleoclimate, but present understanding of the Earth's climate dynamics and a summary of the numerical tools used nowadays will be briefly covered. Review lectures will be presented on paleoclimate record (deep sea cores, continents, ice cores), and long-term climate data analysis, modeling, and astronomical forcing. Milankovitch's life and work, the colorful memories he has of the events of his time and his opus as a poetic science writer will also be highlighted. The symposium will consist of invited lectures, but will include poster sessions to accommodate contributed papers.

For more details
http://www.ngdc.noaa.gov/paleo/meetings/milankovitch.pdf

or contact:
Prof. M. Ercegovac:
milankovitch-erc@sanu.ac.yu

AQUA 2004 Biennial meeting

6–10 December, Cradle Mountain, Tasmania.

For more details please visit
http://aqua2004.anu.edu.au/

8th Australasian Environmental Isotope Conference

The 8th Australasian Environmental Isotope Conference will be held in Melbourne from Monday, 29 November–Wednesday, 1 December, 2004.

This is the latest in a long-running series of conferences dedicated to the application of stable and radiogenic isotopes to studies of environmental processes.

As with previous conferences in this series, we invite presentations on applications of stable, radiogenic, and cosmogenic isotopes to understanding the natural environment. Topics include:

- Climate and environmental change
- Groundwater and surface water
- Soils
- Landscape evolution
- Applications of cosmogenic isotopes
- Dating
- New analytical techniques and applications

Further information can be found at
http://www.earthsci.unimelb.edu.au/conferences/index.html

The climate of the next millennia in the perspective of abrupt climate change during the late pleistocene pages/deklim Conference

Convenors: Frank Sirocko, Jerry McManus, Martin Claussen, Keith Alverson
Date: 7–10 March, 2005
Location: Mainz, Germany

Call for Papers: 'The climate of the past is the key to understanding the climate of the future'. Is this often-used statement truly correct for the next two millennia? The conference will examine past records of abrupt climate change and discuss if the processes that caused past abrupt change are relevant for the Holocene and predicted climate evolution. Keynote lectures on the mechanisms that dominated past climate evolution will be followed by sessions (talks and posters) on long (0–3 Ma), medium (0–150 ka) and very short (Holocene and last millennium) time scales. Discussions are intended to separate processes unique to the past from those that have the potential to effect global climate during the next millennia. The conference is sponsored by the German DEKLIM program (www.deklim.de) and represents a German contribution to PAGES. We hope to welcome you in Mainz (50 minutes from Frankfurt International Airport) and would appreciate your early registration.

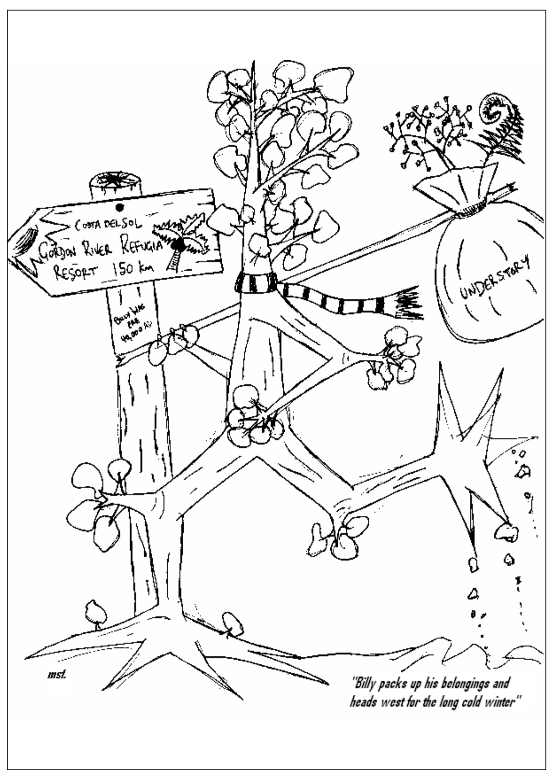
For Registration details please contact:
Saskia Rupert
email: rudert@mail.uni-mainz.de
Conference documents can also be downloaded at
http://www.uni-mainz.de/FB/Geo/Geologie/sedi/en/index.html.

Friends of the Quaternary (Pleistocene & upper Pliocene) field trip

Wanganui Basin, 20–22 August, 2003
Co-organised through the Geological Society of New Zealand (GSNZ) and the Australasian Quaternary Association (AQUA)

Immediately prior to a NZ-INTIMATE workshop scheduled at GNS-Gracefield on 23–24 August (programme yet to be announced). As the majority of NZ Plio-Pleistocene stages have been defined from Wanganui Basin, this field trip offers an opportunity to discuss the proposed redefinition of the Quaternary System.

For further information and/or registration details please contact:
Brent Alloway
(b.alloway @gns.cri.nz)
GNS, Wairakei Research Centre,
Private Bag 2000, Taupo



M. Fletcher, SAGES, University of Melbourne

QUATERNARY AUSTRALASIA

Quaternary Australasia publishes news, commentary, notices of upcoming events, travel, conference and research reports, thesis abstracts and peer-reviewed research papers of interest to the community. Non-refereed material should reach the editor by 1 November, 2004. Please ensure that citations, in both refereed and non-refereed manuscripts, are formatted to conform to Quaternary Australasia style. An Endnote 7.0 for Mac style file is available on request.

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

Quaternary Australasia Editor
Mr Kale Sniderman, Monash University
School of Geography and Environmental Science
Bldg 11 (Menzies), Victoria 3800
Ph: +61 (0) 3 9905 2919, Fax: +61 (0) 3 9905 2948
Email: kale.sniderman@arts.monash.edu.au

Australian Quaternary Association

Committee Members