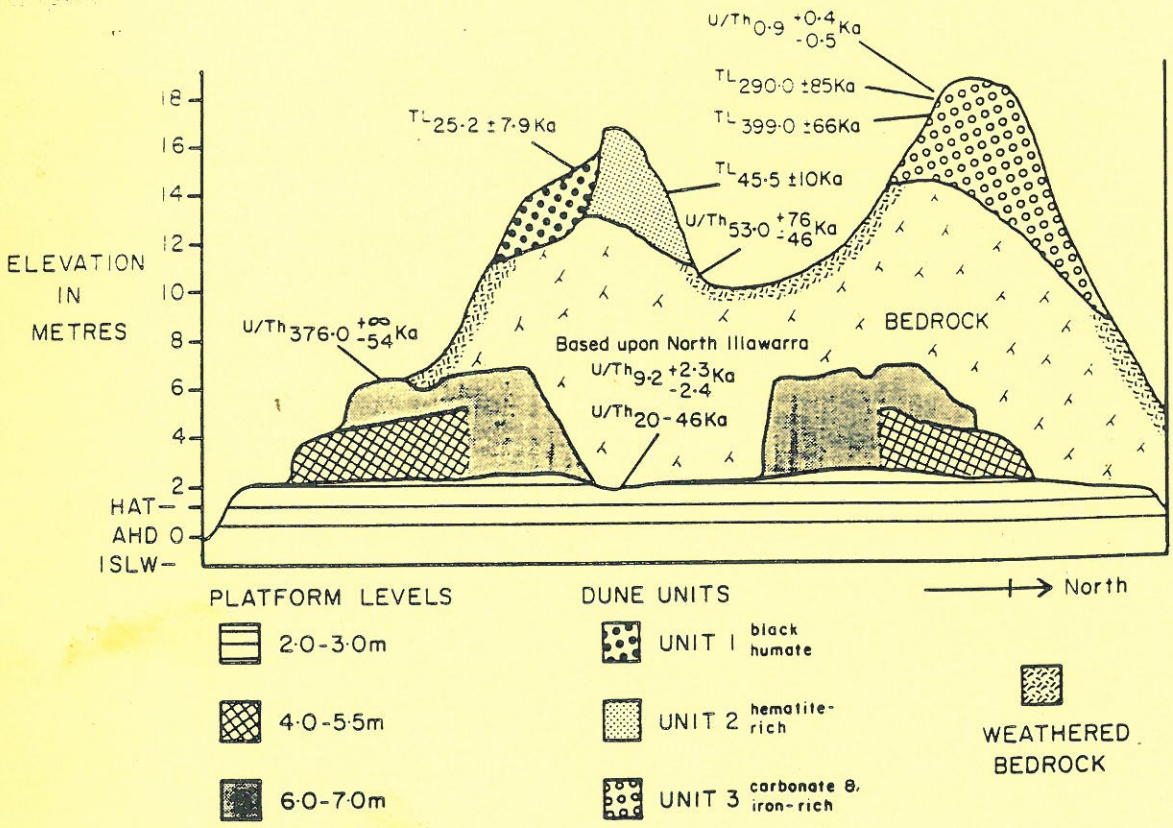
Quaternary Australasia

The Newsletter of the Australasian Quaternary Association



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QUATERNARY AUSTRALASIA, VOL 9/1, APRIL 1991

Material for the next issue should reach the editor by **31 August 1991:**

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The **AUSTRALASIAN QUATERNARY ASSOCIATION (AQUA)** is an informal grouping of people interested in the manifold phenomena of the Quaternary. It seeks to encourage research by younger workers in particular, to promote scientific communication between Australia and New Zealand, and to inform members of current research and publications. It holds biennial meetings and publishes the Newsletter **'Quaternary Australasia'** twice a year. The annual subscription is $A20 or $10 for students, unemployed or retired persons. President 1989 - 1991 is Dr. Lesley Head, Department of Geography, University of Wollongong, Wollongong, NSW.

CONTENTS

Forthcoming papers include:

- Tasmanian speleothems: progress and prospects for palaeoenvironmental reconstructions (Goede)
- Surface microtexture study of Lake Quaternary aeolinite by SEM... (Liping, Williams & Peterson).

EDITORIAL

Welcome to 1991's first issue of *Quaternary Australasia*. It has been a great pleasure to receive the many papers and notes that you will find within these and the next issue's covers. It is most encouraging to receive such support for our journal. As you will see, the presence of these contributions has allowed me the luxury of cutting back on some of the other material which featured so much in previous issues. I think it is still important to publish things like the conference lists and recent publications list, and would be more than delighted if some willing Quaternarist took it upon themselves to compile these for me! The recent publications list, as you will see, has resorted to its original format, with no supplementary notes; this is largely a function of my workload. Although I received a few encouraging comments about that the content of the recent publications list in the last volume, and consider it a good idea (modesty, eh?) I'm afraid that little things such as teaching commitments and research limit the time a bit! There's nothing new in the world, is there?

The next issue of *Quaternary Australasia* will be put together while I am on study leave in New Zealand. It would be quite suitable, therefore, to receive papers from our New Zealand members; let's try to shift some of the emphasis over the Tasman Sea. Of course, there will be no problem accommodating publishable material from Australia or anywhere else. All contributions should be sent to me at my University of New England address (see front inside cover) by 31st August; it will be sent on to me. If anyone wants to get in touch with me in New Zealand, I should be based in the Department of Anthropology at the University of Auckland during September.

Finally, I have a request from Barry Warner which he has asked me to pass on to you. Barry writes: "I am interested in purchasing bulk supplies of *Eucalyptus* pollen from a commercial supplier but do not know of any (except a very expensive one in North America). I would like to find a supplier in Australia which I assume would have more reasonable prices." If anyone can help out, please contact Barry directly: Department of Earth Sciences, Faculty of Science, University of Waterloo, Waterloo, Ontario, Canada. Mention where you saw the ad...!

Bill Boyd, Editor

AQUA NEWS

The 1991 Field Meeting at Mallacoota was another success, following the fine tradition of AQUA field meetings. Several of the contributions there are included in this edition of *Quaternary Australasia*. Following the business meeting there, here are the minutes of that meeting, and a copy of the current constitution.

Minutes of Annual General Meeting

AQUA Field Meeting 1991
Mallacoota 9th February, 1991

Apologies
Prof. Eric Colhoun
Dr Mike Barbetti
A/Prof. John Dodson
Dr Bill Boyd

1. Editor's report (Bill Boyd) read by Lesley Head.

2. Treasurer's report (Albert Goede)
   - High interest rates had helped AQUA's finances
   - Balance $17k ($17,692.13)
   - printing cost of journal (newsletter) may increase
   - postage $500.00 for QA in 1990
   - Tax exemption certificates required under new tax laws
   - Tax exemption requires a constitution for AQUA

3. Lesley Head gave a vote of thanks to Albert Goede for his excellent efforts as Treasurer of AQUA and to Bill Boyd for the production of "*Quaternary Australasia*".

4. Lesley Head outlined a draft constitution for AQUA. Amendments were made in group discussion and John Grindrod moved the motion that the constitution be installed. Seconded Prof. Martin Williams. Motion passed unanimously.

5. Incorporation. Gay Crowley discussed the legal implications concerning safety hazards on field excursions and strongly urged that AQUA becomes an "incorporated" organization. Suggested that the constitution be published in "*Quaternary Australasia*". Gay Crowley moved the motion that AQUA be incorporated. Seconded Dr John Pickard. Motion carried unanimously.

6. Election of new AQUA committee
   President: Dr Geoff Hope (Australian National University)
   Secretary: Dr Colin Murray-Wallace (University of Newcastle)

Editor: Dr Bill Boyd (The University of New England - Northern Rivers)

Treasurer: Mr Albert Goede (University of Tasmania)

7. Next AQUA meeting
Dr Peter Kershaw spoke on behalf of Dr Jim Bowler's suggestion of holding a mini-INQUA meeting. Proposal to host a conference in August 1993 with an international flair. The ANU was suggested as a possible venue. Some concern was expressed about the formality of such a meeting, but the general consensus was that the advantages would far out weigh any disadvantages. It was concluded that some formality is required in order to attract people from overseas.

Peter Kershaw pointed out that the meeting should be carried out in a relatively large population centre because of the required logistical support.

Martin Williams moved that open invitations be made to overseas people for the mini-INQA meeting. Seconded: Geoff Hope. Motion passed unanimously. Geoff Hope indicated that the details of the venue and the meeting would be organized by the AQUA committee.

8. John Pickard discussed the responses to his article in "*Quaternary Australasia*" (Vol 8, No. 2 p. 25) on the diets of Diprotodons. John was pleased with the response to his article.

9. Esmee Webb spoke of AQUA and its role in organizing subsidized journal subscriptions in the manner of European Quaternary organization (eg., members of AQUA qualifying for a discount in subs. for the journals QR, JQS and QSR).

10. Awards for paper presentations at the AQUA field meeting Chris Kenyon: Award for excellence of presentation $500.00 Paul Hesse and Jamie Pittock: Awards of Merit $250.00 each.

Meeting closed 9.15pm

Secretary
Dr Colin Murray-Wallace
Department of Geology
University of Newcastle
(049) 215 415

AUSTRALASIAN QUATERNARY ASSOCIATION CONSTITUTION

1. The name of the Association shall be Australasian Quaternary Association (hereinafter called AQUA).

2. AQUA is a non-profit organisation whose objects are:

   a. to promote Quaternary research and teaching;
   b. to provide an organisation for the discussion and dissemination of information and ideas relating to the Quaternary;
   c. to convene meetings at regular intervals;
   d. to publicise the work of AQUA.

3. A person is eligible to be a member of AQUA on payment of the annual subscription fixed under these rules.

4. The income and property of AQUA, however derived, shall be applied solely towards the promotion of the objects and purposes of AQUA and no portion thereof shall be paid or transferred, directly or indirectly, by dividend, bonus, or otherwise, to any member of AQUA, other than the awarding of prizes, scholarships and fellowships in accordance with the objects stated in (2).

5. AQUA shall hold a general meeting at least every two years. This should normally be concurrent with its regular field meeting, but may be called by the Committee at other times if one month's notice is given.

6. The affairs of AQUA shall be managed by a Committee, elected at a Biennial General Meeting and cinstituted as follows:

   a. a President;
   b. a Secretary
   c. a Treasurer;
   d. the Editor of AQUA's publications;
   e. any number of other members that the general meeting may determine. These may be elected at the general meeting or co-opted by the Committee.

7. i. The amount of annual subscription may be altered by the members of AQUA by resolution at a general meeting.
   ii. Any annual subscription of a member of AQUA is due and payable on January 1, or as determined by the Committee.

8. These rules may be amended by resolution passed by a two-thirds majority of AQUA members present at a general meeting.

ii. Any annual subscription of a member of AQUA is due and payable on January 1, or as determined by the Committee.

8. These rules may be amended by resolution passed by a two-thirds majority of AQUA members present at a general meeting.

9. Dissolution shall require a two-thirds majority of AQUA members present at a general meeting. Any surplus funds and assets shall be donated to another non-profit organisation(s) nominated by the meeting.

Accepted by AQUA general meeting, Karbeethong Lodge, Mallacoota, 9.2.91.

1991 COMMITTEE MEMBERS

Finally, just another reminder of who's who on the 1991 AQUA Committee. Note, in particular, our secretary's change of address and the editor's change of phone number.

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DEPARTMENT AND INSTITUTE REVIEWS

THE N.W.G. MACINTOCH CENTRE FOR QUATERNARY DATING, UNIVERSITY OF SYDNEY

RADIOCARBON PRICE LIST

Samples processed in our laboratory

Straighforward samples	$400
Surcharge for bones, or samples with less than 1 gram carbon	$200
Surcharge for bulky samples containing 1 - 5% carbon	$200
13C/12C analysis (in association with radiocarbon dating)	$50

Notes:

i. Turnaround time fluctuates with demand. It is presently about 6 months. However, we are always ready to consider faster turnaround in special circumstances; there is space on our forms for such requests, or you can phone and ask.

ii. There is no additional charge for priority; requests are considered on merit.

Samples we forward to Beta Analytic Inc. Florida, USA:

	EXCHANGE RATE A$1 = USc		
	70-75	75-80	80-85
Straighforward samples, RUSH (3 weeks delivery)	A$510	480	450
Straightforward samples, NORMAL (6 weeks delivery)	A$340	320	300
SUPPLEMENTARY fees for collagen or humate preparation, soils or sediments containing less than 5% carbon	A$210	190	180
OPTIONAL extended counting time (4 x normal)	A$210	190	180
Very small samples (0.3 to 0.002g carbon) by accelerator mass spectrometry, average delivery time 4 - 6 months	A$810	760	720
13C/12C analysis (in association with radiocarbon dating)	A$65	60	55
(RUS priority A$20 extra)	A$85	80	75

Notes:

i. Delivery times include normal postage for you and us.

ii. Prices are in Australian dollars, based on the exchange rate at the time we receive your samples, and include our handling fees. Pleae check current prices before submitting samples.

iii. You will be invoiced by the University of Sydney; if possible, please send a Purchase Order to the Macintosh Centre.

Samples we forward to DSIR Physical Sciences, NZ:

	EXCHANGE RATE A$1 = NZ$		
	1.25-1.30	1.30-1.35	1.35-1.40
Samples with at least 1mg and preferably 4mg carbon, requiring normal pretreatment, results in 6 months	A$700	670	640

The Nuclear Sciences Group, DSIR, Wellington, New Zealand, is one of a small number of laboratories around the world which can measure carbon-14 by accelerator mass spectrometry. The precision is about 1% or +/- 80 years on young samples, and the detection limit is more than 40,000 years. The price includes carbon-13 measurement by independent high-precision (+/- 0.1 per mil) conventional mass spectrometry. Samples requiring special treatment, or smaller than 1mg, can often be accommodated - contact us for details. Samples supplied as clean carbon dioxide gas attract a discount of A$80.

Books for Sale

Please send cheques payable to The University of Sydney. (No orders please!).

THE CAINOZOIC VEGETATION OF TASMANIA
Compiled by Eric A. Colhoun, Department of Geography, University of Newcastle

Reviewed in *Quaternary Australasia*, December 1988, $12.00, postage $5.00

RADIOCARBON USER'S HANDBOOK
by Richard Gillespie, Oxford University Committee for Archaeology, 1986 edition

A 36-page booklet with an introduction and chapters on sample collection, laboratory

procedures, age calculation and interpretation....$5.50.

AUSTRALIAN ARCHAEOLOGICAL ASSOCIATION

The Australian Archaeological Association is an Australia-wide network of professional and no-professional archaeologists. The objects of the Association are:

i. to promote the advancement of archaeology;
ii. to provide an organisation for the discussion and dissemination of archaeological information and ideas in archaeology;
iii. to convene meetings at regular intervals
iv. to publicise the need for the study and conservation of archaeological sites and collections;
v. to publicise the work of the Association.

The Association fulfils these objectives by:

i. organising a conference each year in which student participaiton is encouraged. The AAA attempts to subsidise the fares of those students who present papers at the conference;
ii. producing the journal *Australian Archaeology* twice a year;
iii. lobbying politicians and other relevant organisations and individuals about aracheological issues.

The cost of AAA membership is an initial $5.00 joining fee and an annual subscription of $13.00 for students and $26.00 for others which is due on January 1st each year. Members who have paid their fees are entitled to attend the annual conference of the Association, vote at the Annual General Meeting and receive two volumes of *Australian Archaeology* for each year of subscription.

To join the AAA contact:

Mary-Jane Mountain
Public Officer, AAA
Department of Anthropology and Prehistory
The Faculties, ANU
PO Box 4
Canberra A.C.T. 2601

CONFERENCE REPORT

INQUA: CROMER SYMPOSIUM UNIVERSITY OF EAST ANGLIA, NORWICH, U.K. 2-4 SEPTEMBER 1990

This stimulating symposium, well organized by Charles Turner (Subcommission President) and Phil Gibbard, both of Cambridge University Botany Department, was attended by some seventy participants respresenting fourteen countries, with large contingents from the UK and (what was then still) W. Germany, also workers from E. Germany, Poland and the USSR. Twenty-seven papers and ten posters were presented in two days.

Papers about sites on the northern European plains from the Netherlands to western Russia were mainly concerned with identifying and attempting to correlate cold and temperate phases exposed in artificial sections (boreholes and the walls of monstrous opencast lignite pits). Palynology remains the most potent tool in this endeavour, but vertebrate and invertebrate palaeontology are making major contributions.

Several of the British papers concerned the Kesgrave formation laid down by a Lower to early Middle Pleistocene forerunner of the River Thames, draining a much larger area than the present river, including the uplands of western Britain, where local glaciation during earlier cold phases seems to have been the source of the Kesgrave sediments. These were mostly buried by till from the first major Pleistocene glacial advance (Anglian), which also fragmented the catchment of the proto-Thames. However, in a north-eastward trending arc north from the present Thames estuary to the limit of the Anglian till, Kesgrave units lie at or close to the surface.

The third major group of papers was by mammal palaeontologists. In spite of the number of workers and the diversity of species investigated, mammals appear to be of only limited use as chronostratigraphic markrs. This is probably because (unlike plant microfossils) only presence/absence data are used, and both evolutionary change detectable in morphology and extinction and replacement were slow processes.

The papers were rounded out by contributions on the two important Middle Pleistocene archaeological sites at Mildenhall and Boxgrove.

"Cromer" was the logical name for the symposium, as it has been associated with pre-glacial Pleistocene deposits in Britain for more than a century. However, it soon became clear what a ragbag term Cromerian has become, in spite of R.G. West's attempts to restrict it to a local manifestation of a single interglacial. The time period regarded as relevant to the symposium varied widely among speakers. Although it appeared illogical on the programme, it may have been tactful of the organizers to leave till last Gerry Richmond's paper on the INQUA-approved provisional Lower-Middle Pleistocene boundary at the Matayuma/Brunhes magnetic reversal! (See also the last *Quaternary Australasia* (Vol. 8. No. 2) p. 13). Its position at the end of the programme permitted a lively discussion on the whole symposium. This disclosed a major dichotomy of approach between those who believe in still concentrating on regional stratigraphies (e.g. R.G. West), and those who favour describing all sites in terms of the yardstick of the deep-sea oxygen isotope record (messy for formal stratigraphy).

Clearly a great deal is being done in Europe, but so far it has only generated more questions about the chronostratigraphic relations of sites than it has answered. With their long and often conformable Middle Pleistocene sequences, the northern European plains bore-hole sites, particularly those in the Netherlands, still appear to be the best bet to provide the backbone for future synthetic work. One veteran of such symposia commented to me that at this symposium he found a refreshing new air of cooperation in which people admitted that they did not have all the answers and realized that the situation is much more complex than anyone had anticipated.

The excursions (5 - 7 Sept.) took us to the classic Cromer Forest Bed Formation sections in the cliffs at Sidestrand (upthrust marine sections overlain by glacial till containing blocks of chalk the size of office blocks) and West Runton (Freshwater Bed between marine units and till); Kesgrave formation exposures in quarries (till overlying palaeosols developed on marine units; and coarse gravels with organic lenses), and fossiliferous sediments excavated for us from a river channel 5m beneath the surface; and the Boxgrove archaeological site at Eartham Quarry on one of the West Sussex Middle Pleistocene raised beaches (immaculate excavations and sections revealing flint tool preparation areas and a butchering site on a beach subsequently buried beneath temperate terrestrial deposits and solifluction gravels).

Alex Baynes, Western Australia Museum, Perth.

CONFERENCE AND MEETING NEWS

6-10 May 1991 **First Regional Conference of Geomorphology, Man, his physical environment and natural disasters**, Turkey; contact Turkiye Jeomorfologlar Dernegi P.K. 652, Kizilay, 06425 Ankara, Turkey.

21-23 May 1991 **International Symposium on Landslides and Geotechnics**, Wuhan, China; contact Prof. Dr. Zhu Ruigeng, Inst. of Rock-Soil Environmental Engineering, Wuhan Univeristy of Technology, Wuhan, 430070, China.

19-22 June 1991 **History of Agriculture and the Environment** Washington, USA; contact: Douglas Helms, National Historian, Soil Conservation Service, P.O.Box 2890, Washington DC, 20013, USA.

8-11 July 1991 **Australian Marine Sciences Association Annual Scientific Meeting**, Brisbane; contact AMSA Organizing Committee, Zoology Dept., Univ. Queensland, St. Lucia, 4067, Queensland, Australia.

2-9 August 1991 **International Union for Quaternary Research XIII International Congress**, Beijing, Chinese Academy of Sciences, 52 Sanlihe, Beijing, 100864, China.

10-12 September 1991 **Charcoal, ancient ecosystems and human impact**, Montpellier, France; contact Laboratoire de Paleobotanique, Environment et Archeologie, Univ. de Montpellier Sciences et Techniques du Languedoc, 34095 Montpellier cedex 5, France.

7-9 December 1991 **1991 Australian Archaeological Association Conference; Sahul in Review**, Birrigai, ACT, Australia; contact: 1991 AAA Conference, C/- Dept. Prehistory, Research School of Pacific Studies, Australian National University, G.P.O.Box 4, Canberra 2601, Australia.

10-11 December 1991 **SLEADS (Salt Lakes, Evaporites and Aeolian Deposits) Conference: Arid-zone hydrology, geochemistry, biology, stratigraphy and palaeoenvironments; Australian research with global comparisons**, ANU, Canberra; contact: Allan Chivas, Research School of Earth Sciences, A.N.U., G.P.O. Box 4, Canberra, ACT 2601, Australia.

5-9 July 1992 **International Symposoium on Erosion, Debris Flows and Environment in Mountain Regions**, Chengdu, China; contact: Dr. Shang Xiangchao, Inst. of Mountain Disasters and Environment, Chinese Academy of Sciences, PO Box 417, Chengdu, Sichuan, 610015, China.

9-14 August 1992 **XXVII International Geographical Congress**, Washington, USA: contact Dr. B.Bishop, Committee for Research and Exploration, National Geographic Society, Washington, D.C. 20036, USA, telex 89-2398.

16-23 August 1992 **International Conference of Historical Geographers**, Vancouver, Canada; contact Dept Geography, 217-1984 West Mall, Univ. British Columbia, Vancouver, B.C., Canada.

2-12 September 1992 **8th International Palynological Congress**, Aix-en-Provence, France; contact: Jean-Peirre Suc, Secretary 8th IPC,Laboratoire de Palynologie (case 061), Univ. de Montpellier II, F-34095 Montpeller cedex 5, France.

19-25 April 1993 **Fifth International Conference on Modern and Fossil Dinoflagellates**, Zeist, The Netherlands; Contact Jan Willem Weegink, Lab. Palaeobot. Palynol., Univ. Utrecht, Heidelberglaan 2, 3584CS Utrecht, The Netherlands.

23-29 August 1993 **Third International Conference on Geomorphology**, Hamilton, Canada; contact: 3rd International Conference on Geomorphology, McMaster Univ., Hamilton, Ontario, L8S 4K1, Canada.

RECENT PUBLICATIONS

The following recent publication list is somewhat briefer than in the last edition. Please accept my apologies for this. If anyone is willing to put together a list, I would certainly be pleased to publish it in the future!

3rd IOP Conference Proceedings, (Melbourne, August 1988); copies available from Jack Douglas, Geological Survey of Victoria, P.O. Box 173, East Melbourne, Victoria, 3002, Australia.

Balme, J. & Hope, J. 1990. Radiocarbon dates from midden sites in the lower Darling River area of western New South Wales. *Archaeology in Oceania*, 25, 85-101.

Berger, A., Schneider, S. & Duplessy, J.Cl., 1989. *Climate and geosciences: a challenge for science and society in the 21st century.* Kluwer Academic Publishers, Dordrecht.

Boyd, W.E. 1990. Australian environmental archaeology: A review of some of the main themes. pp.249-262 in Robinson, D.E. (ed) *Experimentation and reconstruction in environmental archaeology*. Oxbow Books, Oxford.

Brown, I.M. 1990. Quaternary glaciations of New Guinea. *Quaternary Science Reviews* 9, 273-280.

Bryant, E.A., Young, R.W., Price, D.M. & Short, S.A. 1990. Thermoluminscence and Uranium-thorium chronologies of Pleistocene coastal landforms of the Illawarra region, New South Wales. *Australian Geographer*, 21, 101-112.

Clapperton, C.M. 1990. Quaternary glaciations in the Southern Ocean and Antarctic Peninsula area. *Quaternary Science Reviews*, 9, 229-252.

Clapperton, C.M. 1990. Quaternary glaciations in the southern hemisphere: An overview. *Quaternary Science Reviews*, 9, 299-304.

Clapperton, C.M. & Sugden, D.E. 1990. Late Cenozoic glacial history of the Ross Embayment, Antarctica. *Quaternary Science Reviews*. 9, 253-272.

Colhoun, E.A. & Fitzsimons, 1990. Late Cainozoic glaciation in western Tasmania, Australia. *Quaternary Science Reviews*, 9, 199- 216.

Cox, C., James, J.M., Osbourne, R.A.L. & Leggett, K.E.A. 1989. Stromatolitic crayfish-like stalagmites. *Proc. Univ. Bristol Spelaeol. Soc.* 18 (3), 339 - 358.

Cox, G., James, J.M., Leggett, K.E.A. & Osbourne, R.A.L. 1989. Cyanobacterially deposited speleothems: subzerial stromalites. *Geomicrobiology Journal* 7, 245 - 252.

Dorn, R.I. and Dragovich, D. 1990. Interpretation of rock varnish in Australia: case studies from the arid zone. *Australian Geographer* 21 (1), 18 - 32.

Dowdeswell, J.A. (ed.) 1990. *Glacimarine environments: Processes and sediments.* Geological Society Special Publication No. 53, Bath, England.

Ehrendorfer, F. 1989. *Woody plants - Evolution and distribution since the Tertiary.* Springer-Verlag, Vienna.

Fitzsimons, S.J. 1989. Lithological stratification in supra, glacial sediments: an example from Western Tasmania, Australia. *Boreas* 18, 127 - 134.

Fitzsimons, S.J., Colhoun, E.A. & Van de Geer, G. 1990. Middle Pleistocene glacial stratigraphy at Baxter Rivulet, western Tasmania, Australia. *Journal of Quaternary Science* 5 (1), 17 - 27.

Fitzsimons, S.J., Colhoun, E.A., Van de Geer, G. & Hill, R.s. 1990. Definition and character of the Regency Interglacial and Early-Middle Pleistocene stratigraphy in the King Valley, western Tasmania, Australia. *Boreas* 19, 1 - 16.

Goede, A. 1989. Electron spin resonance - a relative dating technique for Quaternary sediments near Warrnambool, Victoria. *Australian Geographical Studies* 27 (1), 14 - 13.

Goede, A., Harmon, R.S., Atkinson, T.C. & Rowe, P.J. 1990. Pleistocene climatic change in Southern Australia and its effect on speleothem deposition in some Nullabor caves. *Journal of Quaternary Science* 5 (1), 29 - 38.

Goede, A., Veeh, H.H. & Ayliffe, L.K. 1990. Late Quaternary palaeotemperature records for two Tasmanian speleothems. *Australian Journal of Earth Sciences*, 37, 267-278.

Goudie, A., Viles, H., Allison, R., Day, M., Livingstone, I & Bull, P. 1990. Geomorphology of the Napier Range, Western Australia. *Transactions of the Institute of British Geographers*, N.S.15, 308-322.

Hall, K.J. 1990. Quaternary glaciations in the Southern Ocean: Sector 0 Long. - 180 Long. *Quaternary Science Reviews*, 9, 217- 228.

Hiscock, P. 1990. How old are the artefacts at Malkunanja II? *Archaeology in Oceania*, 25, 122-124.

Keirnen, K. 1990. Underground drainage at Mole Creek, Tasnmania. *Australian Geographical Studies*, 28, 224-239.

Keirnan, K. 1990. The alpine geomorphology of the Mt Anne massif, South-western Tasmania. *Australian Geographer*, 21, 113-125.

Kiernan, K. 1990. Weathering as an indicator of Quaternary glacial deposits in Tasmania. *Australian Geographer* 21 (1), 1 - 17.

Marshall, B. & Cosgrove, R. 1990. Tasmanian Devil (*Sacrophilus harrissii*) scat-bone: signature criteria and archaeological inplications. *Archaeology in Oceania*, 25, 102- 113.

Roberts, R.G., Jones, R. & Smith, M.A. 1990. Stratigraphy and statistics at Malakunanja II: Reply to Hiscock. *Archaeology in Oceania*, 25, 125-129.

Suggate, R.P. 1990. Late Pliocene and Quaternary glaciations of New Zealand. *Quaternary Science Reviews*, 9, 175-198.

Truswell, E.M. & Owen, J.A.K. (eds) 1990. *Proceedings of the 7th International Palynological Congress*. Elsevier, Amsterdam.

BOOK REVIEW

PACKRAT MIDDENS: THE LAST 40,000 YEARS OF BIOTIC CHANGE

Edited by Julio L. Betancourt, Thomas R. Van Devender and Paul S. Martin. The University of Arizona Press, Tucson. 1990. i-vii, 1 - 469. ISBN 0-8165-1115-2

A packrat is one of 21 species of medium-sized herbivorous rodents belonging to the genus *Neotoma*, which inhabit North America between near-Arctic Canada and tropical Nicaragua. (No, Bruce, the soldiers were called Desert Rats). Packrats are of interest to Quaternarians because many species accumulate urine-cemented middens in boulder piles and rock crevices which can persist for up to 50,000 years in desert areas. In the last three decades packrat middens have provided the raw materials for the very detailed reconstruction of late Quaternary plant communities and environments in the deserts of western North America, the only arid area in the world with such a detailed record.

Twenty-two authors including the editors, singly or in various combinations, have contributed 19 chapters which are grouped into four sections titled Methods, Regional Summaries, Special Studies and Middens Abroad. The editors have provided an insightful Introduction at the beginning and Synthesis and Prospectus at the end.

The Methodology section contains chapters on the ecology and behaviour of packrats which attempt to determine whether the accumulated plant foods faithfully reflect the species composition and relative abundances in the surrounding vegetation (clearly not in the case of one or two food specialist packrat species!). The spectacular palaeoecological reconstructions seem to have been achieved, as much in spite of as because of, the characteristics of packrat middens. An analysis of 1113 midden radiocarbon dates up to 1985 reveals a striking bias to terminal Pleistocene middens, collected because they were easily identified by fossils of plants no longer occurring in the vicinity.

Regional Summaries cover the Chihuahuan Desert on the eastern side of the U.S. continental divide, and the Sonoran Desert, Mojave Desert, Great Basin and Colorado Plateau on the eastern side. Reconstructions of plant associations from the middle Wisconsin to late Holocene, reveal an overall common pattern. During the glacial, vegetation formations occurred at some hundreds of metres lower elevation than today, so that the present deserts were largely occupied by pygmy conifer woodland, while the desert scrub, with its characteristic cacti, was reduced to relictual areas at the lowest elevations. Far from being ancient, the current desert plant associations are an interglacial phenomenon, with individual species achieving their present ranges at different times. Palaeoclimatic interpretations of these proxy data are also attempted, with less agreement between the authors. They appear more important in constraining the values inferred from other models, including computer GCM's, than in generating palaeoclimatic data themselves.

The Special Studies compare packrat midden data with local data from pollen and charcoal in Oregon; make rainfall season interpretations of C4 and C3 grasses in the Sonoran Desert since the end of the Pleistocene; document little change in the mammal faunas of the Chihuahuan Desert, and the arthropods of a study area in the Sonoran Desert, using animal remains from middens; and make a speculative investigation of hydrogen isotopes in plant remains from middens.

In Middens Abroad other sources of "midden" data are briefly surveyed: not only hyrax middens in Africa and the Middle East and *Leporillus* nests in Australia but even bird guano deposits as sources of fossil pollen. It is one of the stated aims of the editors to stimulate workers in other parts of the world to emulate the packrat midden studies. So far only three small studies of the *Leporillus* material in Australia have been made. It is deteriorating and a lot has already been lost. Come on everyone out there! What are you waiting for?

This book is far more than just a collection of excellent papers. By their choice of authors and the subjects covered the editors have provided a stage on which not only the information generated by this research can be placed in the spotlight, but also the underlying assumptions can be laid bare and examined. It is a synthesis in the fullest sense.

Alex Baynes, Western Australia Museum, Perth.

INTERNATIONAL UNION FOR QUATERNARY RESEARCH

The INQUA Holocene Commission has recently published its Newsletter Number 3. The contents of the Newsletter are as follows:

Copies of the Newsletter can be obtained from John Bintliff, Secretary of the Holocene Commission, Archaeology Department, Durham University, UK.

THE QUATERNARY WITHIN IGCP

Quaternary related projects within the framework of IGCP continue to be of interest and importance. Following the list of IGCP programmes published in the last issue of *Quaternary Australasia*, here are the contents of a recent Newsletter issued in June 1990 for the IGCP 296 programme, Quaternary of Asia and the Pacific:

Copies of the Newsletter can be obtained from Dr. Paul Bishop, Department of Geography & Environmental Science, Monash Univeristy, Victoria 3168, Australia.

PAPERS

INTERIM REPORT ON RECENT ARCHAEOLOGICAL RESEARCH ON RAROTONGA, SOUTHERN COOK ISLANDS.

Douglas G. Sutton, Anthropology Department, University of Auckland.

and

John Flenley and Warwick Barker, Geography Department, Massey University, Palmerston North, New Zealand.

Background

This report describes recent research on Rarotonga, funded by Kyoto University through the generosity of Dr Kazu Katayma, Laboratory of Physical Anthropology, Faculty of Science, Kyoto University, Sakyo-Ku, Kyoto.

The research focuses on first colonisation of the Southern Cook Islands, which is the most pressing problem in the archaeology of the region at present. A widely accepted scenario of first colonisation of Polynesia, proposed by Sinoto (1968) is no longer adequate. Following Kirch's (1986) critique of that model, prehistorians are searching for empirical evidence to support an alternative view, first suggested by Biggs (1972). Biggs' argument was that ancient Polynesians would not have undertaken the epoch voyages implicit in Sinoto's model. Rather, he proposed they would have settled continuously from west to east on the principle of nearest neighbour first, thus minimising voyage distances and risks.

At present dates for first colonisation in Hawaii, Easter Island, and the Marquesas are all earlier than those for the Southern Cook Islands (Kirch 1986). This is very enigmatic. Either the Cook Islands was missed by the first Polynesians, as they sailed west to east, or archaeologists working in the Southern Cooks have not identified and dated the earliest cultural deposits there.

The most plausible explanation for the non-discovery of colonisation period settlements in the Southern Cooks is that they are now hidden by sediments deposited since colonisation, leaving only very recent settlements on the current land surface for archaeological scrutiny. This explanation is suggested by the results of research on Aneityum (Groube 1975; Spriggs 1981) and Lakeba (Hughes, Hope and Latham 1979). Earliest sites were difficult to identify on those islands and it was argued that a large proportion of the present flat land on each was formed by depositional processes intitiated or accelerated by anthropogenic forest clearance.

In this situation it is necessary to investigate first colonisation using research techniques which are independent of the archaeological record per se. This is widely recongised and consequently attempts to define date of first colonisation using combinations of archaeological and earth sciences techniques are underway for Aitutaki (Allen n.d.), Aitu (Flenley 1988), Mangaia (Kirch, Flenley and Steadman n.d.), Mauke (Walter n.d.) and Rarotonga, see also Parkes, Flenley and Johnston (1987). Irwin (1989) has predicted that people were in the southern Cooks at 3000 B.P. However, notwithstanding the recent spate of research, there are no archaeological dates of more than 1000 B.P. at the time of writing (23/2/1990; Walter, n.d.; Flenley, pers. comm., 1990). Research on Rarotonga is described below.

Field Research, February 1990.

The authors spent February 3-15th 1990 on Rarotonga. We agreed that the coastal platform was probably formed recently, possibly within the period of human presence and set out to establish whether this was the case. Swamps on the coastal platform were interpreted tentatively as remnants of the former lagoon. Our goal was to investigate these remnants; to define their depths, ages, modes of origin and scientific potential.

Flenley suggested that the best places at which to core the swamps were at the maximum distances from rivers, where sediments from the island core would be thinnest. Initially, we searched the topographical map of Rarotonga (Lands and Survey 149, 4": 1 mile, 50' contour) for interfluvial swamps. We then visited these, and many other swamps shown on and the Land Use Map of Rarotonga (Lands and Survey 146/1 & 2). All the swamps we saw were ranked in a order of priority and we cored down, as it were, from the top of the list.

The equipment used was a modification of the Heller core borer, known as a Thomas borer, and a Feek borer. The latter, named for the person who built it at Massey University, was designed for coarser and tougher sediments than the Thomas borer can penetrate. It is driven by a hand-held rammer, or a 10lb steel hammer. The rods we took to Rarotonga enabled us to core to 7.5 metres with the Thomas borer and 4.5 meters with the Feek borer.

We cored in 6 swamps. The following is a brief description of the locations and results of coring. More accurate descriptions cores will be provided in a full report. Locations will be identified in that paper using aerial photographs.

Atupa

This is the largest area of swamp in Rarotonga, judging from the topographic map. It was substantially modified by the construction of

the International Airport, early in the 1970's. However, a large area of wetland garden and feral swamp remains.

We cored at five places along a transect through the swamp from a point on the Ara Metua approximately 500 yards west of the road from the inner road to Avatiu. We defined the area of deepest deposit along that transect, referred to as AT1 in Table 1, and sampled the deposit there at 10cm intervals, taking radiocarbon samples each metre, to a depth of 3.50m.

The Latter Day Church Site, Arorangi

This site consisted of a narrow swamp, only 20 metres wide, which paralleled the coastline, just inland from the LDS church south of Arorangi. This swamp is shown on the topographical map as a corridor of clear land running through an area of coconut plantation and bush which crosses the district boundary between Arorangi and Muriavai.

We cored at three locations within the swamp and found the deepest spot (ARM1) which was sampled (as above), using the Feek corer, to a depth of 4.50m.

Aroa Taro Swamp

This site is located near the Aroa Radio Station, some 600 yards due north of the Rarotonga Hotel. It is a broad band of taro swamp, intensively used, which extends from the rear of the coral sand beach deposit, approximately 80 metres inland to a high bank which may be an old shoreline. We cored at 4 spots along a transect approximately perpendicular to the coastline, defined the deepest spot (AO1), which was at the inland edge of the swamp gardens, and sampled (as above) using the Thomas corer to a depth of 3m.

Matavera

After exploratory cores, and improvisation of an additional 7.6m of rods, we sampled (as above) a continuous 11.5 metres into the deposit at a location (MR1) approximately 25 metres from the Tupapa road in the seaward west central portion of the Matavera swamp.

The base of the column was an orange clay similar to those formed by the weathering of the Rarotongan basalts. No coral sand was encountered, although the base was apparently below current sea level.

We subsequently cored to 7.5 metres, to record stratigraphy, in two locations near the inland margin of the swamp and, to define depth, in a lobe of the Matavera swamp, northeast of the main swampy area.

Muri

John Flenley and Warwick Barker cored along a transect of the Muri swamp, in Aremango district. Two buried soils overlying a basal coral sand, 1 metre below the surface, were sampled for radiocarbon dating but no pollen was collected due to the unsuitable nature of the deposit.

Avatiu

Finally, we cored to establish depth at several locations within the Avatiu swamp. These were; immediately west of the road to Avatiu from the Ara Metua, and north of the inner road opposite the Ruatonga Stream. A coral sand or gravel base was found a short distance beneath the surface throughout this area. The intervening deposit was composed predominantly of soils with a high inorganic content, unsuitable for the preservation of pollen.

Analysis and Comment

Radiocarbon results from 4 locations are shown in Table 1, where sample depth (cm) is given with each sample number. Preliminary interpretation in the field by Flenley suggested that the Matavera deposit dates back several thousand years and thus provides a record of vegetation change and sedimentology over a long period, including first human colonisation. This is confirmed by the MR1/940-950 result, which is very similar to dates from basal sediments on Aitu and Mitiaro (Parkes, Flenley and Johnston, 1989:13).

The depth of the Matavera deposit is puzzling. Two explanations were discussed during fieldwork. These are:

1. The basin there may have formed as river valley during a period when sea level was much lower than at present and then dammed by reef and beach formation, and infilled, as sea level rose.

2. It may be a solution depression, around the island core, similar to the situation on Mangaia (Stoddart, Spencer and Scoffin 1985, see also Yonekura et alia 1987). Solution depressions form as freshwater, flowing in from the island core, reacts chemically with the reef coral and erode it.

Seismic or resistivity survey of the bottom profiles of the Matavera swamp would probably discrimate between these possibilities, see for example Darwin, Ferring and Ellwood (1990).

It is possible to core into the deep at Matavera because that is the point of greatest interfluvial distance and greatest distance back to the island core. These maximum distances minimise the amount of clay and overburden which has deposited in the swamp from erosion of the

TABLE 1: RAROTONGAN RADIOCARBON RESULTS

Lab #	Sample #	C-14 Age Year BP ± 1o	C13/12	C13 Adjusted Age
Beta-37134	AO1/90-100 RC (sediment)	350 ± 100 BP	-23.4 0/00	380 ± 100 BP
Beta-37135	AT1/150-160 RC (sediment)	1410 ± 80 BP	-26.4 0/00	1380 ± 80 BP
Beta-37136	ARM1/160-170 RC (sediment)	1120 ± 70 BP	-26.1 0/00	1100 ± 70 BP
Beta-37137	MR1/940-950 RC (sediment)	7680 ± 100 BP	-28.8 0/00	7620 ± 100 BP

These dates are reported as RCYBP (radiocarbon years before 1950 AD). By International convention, the half-life of radiocarbon is taken as 5568 years and 95% of the activity of the National Bureau of Standards Oxalic Acid (original batch) used as the modern standard. The quoted errors are from the counting of the modern standard, background, and sample being analyzed. They represent one standard deviation statistics (68% probability), based on the random nature of the radioactive disintegration process. Also by international convention, no corrections are made for DeVries effect, reservoir effect, or isotope fractionation in nature, unless specifically noted above. Stable carbon ratios are measured on request and are calculated relative to the PDB-1 international standard: the adjusted ages are normalized to -25 per mil carbon 13.

island core. It remains to be seen whether there is a circumferential solution depression around Rarotonga, now buried by erosion debris.

Whatever the explanation of its origins the Matavera swamp is now identified as a rich source of data which will clarify the palaeoecology and prehistory of the southern Cook Islands. Samples recovered from there and other locations will indicate the date of first colonisation and elucidate the scale of landscape change which has ensued since that time, as well as the ecology of the island prior to human arrival.

It is necessary to note that the information content of pollen cores relates predominantly to the valley or watershed they are taken from. This degree of localisation means that identification of the date of first colonisation would be most reliable if supported by several cores, rather than one, even on a small island such as Rarotonga.

The samples dated from Atupa (AT1) and the Latter Day Church Site, Arorangi (ARM1) are from approximately half-way down their respective cores. Their ages (Table 1) suggests that basal dates of 2000 years ago or more can be expected from each of those locations. Therefore, the large scale alluviation and infilling of the lagoon which has occurred at those sites, and in other parts of Rarotonga, may post-date human arrival, at least in large part.

Research programme

February's fieldwork in Rarotonga is the initial step in an ongoing research programme. There are three, largely sequential, parts to this programme. Our initial palynological survey is reported here. It and the related laboratory analysis, now underway at Auckland and Massey, comprise Part One. An intensive palaeoecological investigation centred on the Matavera swamp is to follow, as Part Two. Further sampling and a seismic survey will occur during August 1990.

Archaeologists will, quite correctly, be reluctant to accept palynological-geomorphological evidence alone as proof of the date of first colonisation. Therefore, we must find stratigraphically-secure cultural deposits from the colonisation phase and excavate them. Excavation of buried archeological deposits, only one of which is known at present, will be the third and final part of the project. It will begin in August 1990.

Analysis of the Matavera core has begun. Warwick Barker has prepared 11 samples and counted 3 of them (upper, middle and basal), and found the core to be pollen-bearing throughout. Caradoc Peters, who is a Ph.D. candidate in Anthropology at the University of Auckland supervised by Roger Green, John Flenley and Douglas Sutton, is analysing pollen from all cores obtained during February and planning research in Rarotonga from August 1990.

Acknowledgements: We are most grateful to our Japanese colleagues for funding and other support which made this research possible. Thanks are also due to Tony Utunga for issuing our research permit on behalf of the Cook Islands government and to the Cook Islanders who gave us access to their land.

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SILLIMANITE: A POTENTIALLY USEFUL INDICATOR MINERAL

By Ken Rowe, Department of Geography and Environmental Science. Monash University, Clayton, Victoria.

Introduction

In the early stages of a project examining the hypothesis that aeolian accessions had influenced the soils in the foothills of the Eastern Highlands of north-eastern Victoria, indicators of an allochthonous origin for the fine sediments were sought. The possibility of using pollen analysis was considered.

Two samples of clayey sediments from the Tallangatta area were processed for pollen analysis. One was a laminated silty clay from an alluvial terrace mapped as Pliocene and the other was a dark clay from the subsoil layer of a hillside fan, mapped as Shapparton formation (Pleistocene-Recent) (O'Shea, 1979). The fineness and laminar structure of the former and the darkness of the latter suggested they may contain pollen which could be a useful indicator of the origins of the sediments.

Standard processing for preparation of pollen slides, as used by the palynology group in the Geography and Environmental Science Department was used to prepare duplicate sets of extract for making the slides. This involves, among other treatments, the digestion of the sample in hydrofluoric acid to remove the silicate minerals.

Results

Some unidentified plant material, possibly leaf epidermis, was found in the Pliocene terrace sample, and a fern spore was found in the fan sample, but pollen was absent from both. However, samples from both sites had numerous needle-like crystals (Plate 1), the fan sample having the greater number. The crystals are transparent and often appear to have a dark longitudinal line which could have been an axial canal or could have indicated the presence of several crystal faces. As the processing is intended to remove the silicate minerals, the crystals were puzzling. The only known minerals which seemed to fit the general characteristics of the crystals should have been destroyed by the treatment. Initially it was though that the preparation may have been at fault so another sample of the terrace clay was prepared by another experienced operator. The crystals were still present. Another sample was dispersed and a drop of the suspension was examined under the microscope. The crystals were still present, but were much fewer. The pollen processing, which significantly reduces the amount of soil material to a small quantity of residue obviously resulted in concentration of the cystals.

The possibility that they were sponge spicules was rejected because of the consistently straight formand short angular terminations, and the improbability of spicules surviving the pollen treatment.

One of the processed samples from the fan site, which had been suspended in silicon oil, eas cleaned by washing in tetra-butyl-alcohol (TBA) and absolute alcohol with centrifuging. The cleaned and dried powder was used to prepare a slide for electron microprobe (EMP) analysis by sprinkling a small quantity of the powder on a thin layer of araldite on a microscope slide. The remainder of the powder was used for XRD analysis.

The EMP data indicated the crystals were Al_2SiO_5, - probably sillimanite. The XRD analysis confirmed they were sillimanite.

Sillimanite is an aluminosilicate found in regionally metamorphosed argillaceous sediments. It is the product of high temperature and moderate stress and has a specific gravity of 3.23 (Read, 1976). Dan (1959) points out that sillimanite is a comparatively rare mineral, found as a constituent of gneiss and schist in the highest grade of metamorphic rocks, and is rarely a contact metamorphic mineral.

The dominant rock type in the Tallangatta area where the study is being undertaken is the Rubyview Gneiss, described by O'Shea (1975) as "... grey, fine to coarse grained gneiss. Banded, or massive, poorly foliated, granitic in composition". This is part of the regionally metamorphosed Omeo Metamorphic Complex (Morand, 1988). Kerber 91978) concluded that this area is actually a granitic intrusion into the Rubyview Gneiss and refers to it as the Lockhart Granite. She describes the composition as being "... very similar to the Vethanga Granite migmatites, displaying sillimanite and biotite schlieren and granitic segregation at the edges".

Survival of the sillimanite crystals through the comprehensive weathering of the parent material, erosion, transport and deposition, and the subsequent laboratory processing, including the hydrofluoric acid treatment, indicates that the mineral is highly resistant. Its appearance in pollen samples from elsewhere could be a useful indicator of the provinence of the sediments. Conversely, if clay samples from the Tallangatta area where the gneissic rocks are presumed to be the parent material, do not have sillimanite crystals, there is reason to suspect the material as having an origin outside the area.

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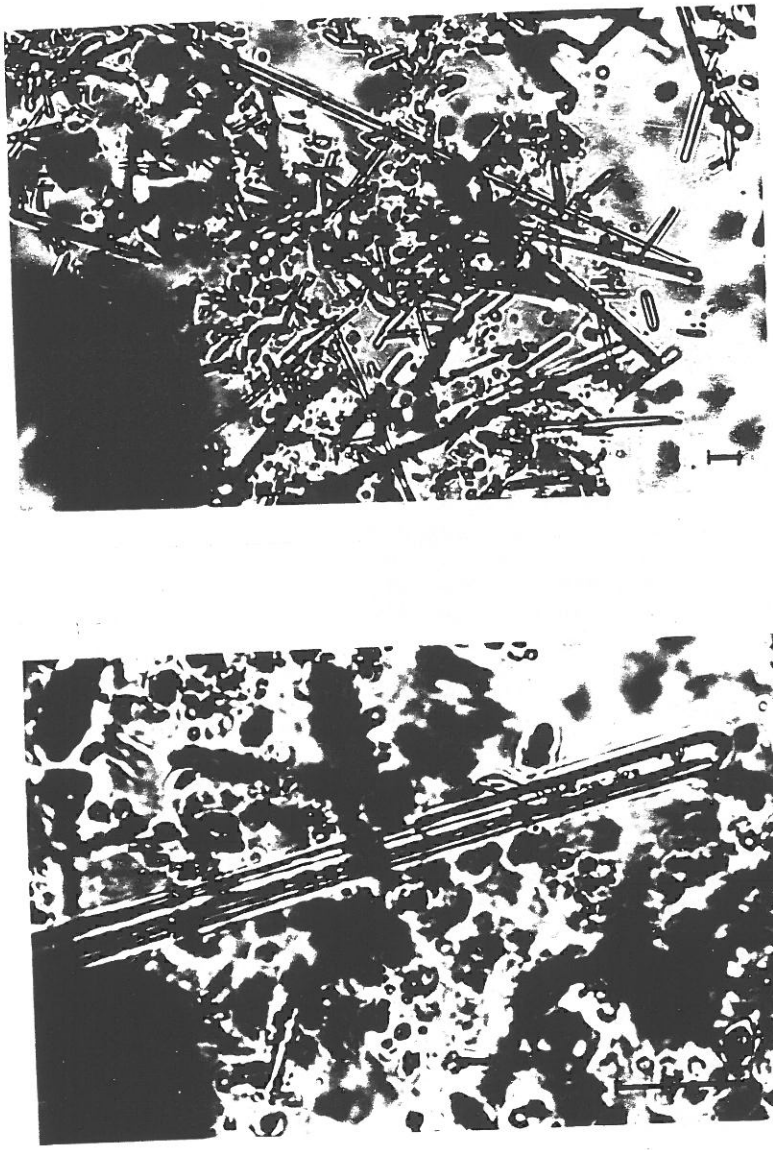

Sillimanite crystals from pollen sample residue. Bar scale = 0.01mm

A LATE PLEISTOCENE AND HOLOCENE PALAEOECOLOGICAL RECORD FROM BOULDER FLAT, EAST GIPPSLAND, VICTORIA.

Christine Kenyon

Abstract of paper presented to the 1991 AQUA Conference, Mallacoota, February, 1991.

Boulder Flat is an alluvial valley (140m ASL) of the Errinundra River, East Gippsland, Victoria.

Ten cores from the swamp at Boulder Flat were used to derive a sedimentary history of swamp development and river hydrological responses to climatic change. Six radiocarbon dates provide a chronology for the deposits. Analysis of pollen and plant macroremains were used to describe regional and local vegetation changes for the period 26,700 years B.P. to the present.

During the maximum of the last glacial (20,000 - 18,000 years B.P.) vegetation consisted of *Eucalyptus* woodland with a diverse assemblage of grasses, alpine herbaceous taxa and cool and warm temperate rainforest species. From 13,250 - 11,250 years B.P. climatic amelioration resulted in catchment instability, erosion and hydrological changes in the Errinundra River which became the dominant influence on the swamp deposits. Between 11,250 and 10,000 years B.P. wet sclerophyll forest and riparian vegetation expanded. After 10,000 years B.P. maximum expansion of the rainforests occurred. This was followed by a mid-Holocene period of less effective precipitation and more open forests. Wet sclerophyll forest again returned as conditions became wetter and continued to expand until European arrival in the region.

The macrofossil data complemented the palynological record and verified the presence of riparian taxa at Boulder Flat during the last glaciation. Fire has been an integral part of the regional environment but climate has been the major determinant of the vegetation throughout this period. There is some evidence for possible Aboriginal management of the local resources by firing of the swamp vegetation, but this needs to be examined in greater detail.

COLONISATION AFTER LITTLE ICE AGE GLACIERS IN THE YUKON: PLANTS DON'T WALK UPHILL.

John Pickard, Graduate School of the Environment, Macquarie University, NSW, 2109

Abstract of paper presented at 1991 AQUA Conference, Mallacoota, February 1991.

Vegetation succession is one of the oldest and most enduring models in plant ecology. Although originally developed by Clements (e.g. 1916), Odum (1969) enunciated the most explicit statement: "(1) It is an orderly process of community development that involves changes in species structure and community processes with time; it is reasonably directional, and therefore, predictable. (2) *It results form modification of the physical environment by the community*; that is, succession is community-controlled even though the physical environment determines the pattern, the rate of change, and often sets limits as to how far development can go. (3)...."(italics added). Drury & Nisbet (1973) examined successional models and found them severely lacking. However, the idea is intuitively appealing and has still not been replaced by another model with such apparent wide application. Thus, many texts still refer explicitly to the model.

The classical model of succession in front of retreating glaciers suggests that bare ground is colonised by lichens, then mosses, then early pioneer vascular plants and finally a mature climax community. At each stage, the plants modify the environment and make it more suitable for the next phase (See (2) above). In this paper I present (limited) data which are inconsistent with this model.

During the Little Ice Age, glaciers at Keele Peak, Yukon Territory, Canada (63° 26'N 130° 30'W) advanced perhaps .1km beyond their present position. Subsequent retreat has exposed till and bare rock which is now being colonised. Lateral moraines of the maximum advance are at least 1,000m below adjoining ridge lines. The moraines are tentatively dated at 1727 AD by applying Rampton's (1970) equation for lichen growth. Slopes would have been vegetated above the fully advanced glaciers, and large vegetated meadows existed between some glacier snouts.

Vegetation data show that up to 2/3 of the species colonising exposed areas also occur on hillsides above the lateral moraines. Colonisation could have occurred when propagules fall downhill. This is inconsistent with the classical models, but is considerably simpler. Given that the most recent advances of glaciers were in the Little Ice Age, and that most of these did not fill the valleys to "bank full" stage, it follows that there would have been considerable vegetation on hillsides above the fully advanced glaciers. This vegetation is the most likely source for most of the colonising vegetation following retreat. Further data are needed to test this alternative model.

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FLOOD HISTORY OF THE LIMESTONE RANGES, KIMBERLEYS, WESTERN AUSTRALIA

David Gillieson, Department of Geography & Oceanography, University of New South Wales, Australian Defence Force Academy, Canberra, A.C.T.

David Ingle Smith and Mark Greenaway, Centre for Resource & Environmental Studies, Australian National University, Canberra, A.C.T.

Mark Ellaway, Department of Geography, University of Melbourne, Parkville, Victoria.

Paper presented at the 24th Institute of Australian Geographers Conference, Armidale, September 1990. (A full version has been submitted to *Applied Geography*).

Background and Study Sites

The estimation of extreme flood discharges is of practical importance for the design of hydrological structures, especially for dams and for flood mitigation works that require information on rare events. Statistical techniques (such as Log Pearson III analysis) that are used to extrapolate extreme discharges from limited runs of measured flow data often result in estimates that differ markedly from one technique to another, and which have such wide confidence limits at low recurrence intervals as to be meaningless. Here we present the results of a field study designed to investigate the magnitude of palaeofloods in an area of northwestern Australia, using Quaternary science methods.

In outline, palaeoflood techniques are based upon the occurence of slackwater deposits. These are deposited at sites sheltered from high velocity flows, and ideally form sedimentary sequences in which individual flood events can be discerned. Slackwater deposits are formed from fluvial sediments that were transported as suspended load. They are therefore characterised by a relatively narrow size range and are generally well sorted. Once such deposits are located they are described in section and the site surveyed to establish height above the thalweg. Suitable material is collected for dating by various absolute techniques, principally radiocarbon and thermoluminescence. The next step is to model the discharges corresponding to the slackwater deposits. The requirements for such flood reconstructions are detailed surveyed cross-sections and field estimates of roughness, as Manning's n values. The calibration of such models in palaeoflood hydrology is aided if detailed information is available for a recent flood trimline.

The best sites for palaeoflood research are those at which good preservation of slackwater deposits is likely, where the height range of flood discharges is large, and where the flow is confined in bedrock channels. Such sites are frequently found in bedrock gorges under semi-arid climates where subsequent disturbance of the deposits is minimal. The Royal Geographical Society - Linnean Society Kimberley Project provided an ideal opportunity to apply palaeoflood techniques to the gorges in the Limestone Ranges of Western Australia.

The Devonian reef complexes of the Napier and Oscar Ranges have been exhumed from a cover of Permian sandstone. As a result, the Lennard River and its tributaries have formed gorges of superimposition where they cut through the limestone reefs. The two major gorges are Windjana, on which this study is based, and Geikie, for which a reconnaissance study was undertaken. Windjana Gorge has been cut through the Napier Range by the Lennard River, which drains approximately 1200km^2 of low to moderate sandstone terrain in the King Leopold Range to the north of the gorge.

The Kimberleys are located in the monsoonal region of northern Australia. The rainfall regime is dominated by marked wet and dry seasons. On average 85% of the annual precipitation of some 650mm falls in the period December to March. For the driest quarter of the year the average is less than 10mm. Much of the rainfall in the "wet" occurs as heavy falls, the mean rainfall per rain day in the wet season is in the range 16.8-18.0mm. Estimates of maximum rainfall intensities are 80 to 90 mm/h (one hour intensity, 50 year recurrence interval; Institute of Engineers, Australia 1987).

Slackwater Deposits and Their Analysis

Palaeoflood estimation was achieved using the WASP model (Crouch, 1979). This is a step-backwater analysis similar to the HEC2 program used by Baker and Pickup (1987). It differs in that the WASP model allows Manning's n values to be specified for left, centre and right channel locations for each reach of the study channel. This gives better simulation of energy losses. Roughness coefficients (Manning's n) were based on Barnes (1967) and values recorded for Australian rivers. Values used range from 0.015 (ripple bed sand, no vegetation) through 0.080 (dense trees with understory) to 0.160 (rock walls with talus, gallery forest with dense understory). The model was calibrated against the known distribution of flood debris and watermarks for the most recent flood by adjusting Manning's n.

The stratigraphy of the slackwater deposits (SWD) is relatively simple. Most deposits recorded were thin (less than 50cm) veneers of sand resting unconformably on bedrock benches or colluvial fans. They had either no discernible stratification or faint horizontal stratification. These are the slackwater terraces of Baker (1987), and represent the minimum flood stage

for each event. In part the correlation of the slackwater deposits was achieved by comparison of the particle size distributions and the degree of reddening of the sand. Five distinct slackwater deposits were identified by this correlation and from consideration of their elevations. Of these, the upper two (SWD4 and SWD5) have incipient soils with a strong red-brown colour.

Samples for radiocarbon dating comprised charcoal, leaves and freshwater mussel shell. It was not possible to obtain an environmental correction for the apparent age of modern shells. Charcoal from SWD1 (ANU 6472) has a $D^{14}C$ activity of 291.6% modern and is in atmospheric equilibrium. Comparison of this result with the atmospheric ^{14}C activity of the SW Pacific suggests that the most likely age is either 1962-3 or 1980. We prefer the latter because it more nearly coincides with a known flood in 1983. Two radiocarbon ages of 250±70 BP (ANU 6474) and 450±70 BP (ANU 6473) on mussel shell are environmentally uncorrected. ANU 6473 provides a maximum age for SWD2 (and SWD1), while ANU 6474 provides a minimum age for disturbance of SWD5.

Thermoluminescence (TL) dating was performed on the coarse fraction (92-125μm) quartz grains. Water, uranium, thorium and rubidium contents are all low, and the TL glow curves showed reasonably good plateaux suggesting a stable signal. Results were calculated using both residual and partial bleaching methods. Dose rate was calculated from the U, Th, Rb and K contents for each sample using the conversion factors of Aitken (1985). Average palaeodose values of a sample obtained by the two methods are in good agreement within one standard deviation. The partial bleaching method results may be less reliable as the TL curve grown by additive doses may not be linear as assumed. Therefore the residual method results are preferred in this study. SWD5 has a TL age of c. 2800 BP while TL ages from the other high level deposit (SWD4) are in good agreement at c. 2000 BP. This is consistent with the stratigraphy and suggests two distinct flood events.

The flow simulation of Windjana Gorge indicates that the lowest two slackwater accumulations (SWD1 and 2) are recent and fall within the range of the mean annual flood. A slackwater accumulation may only be preserved if it can be deposited on an alluvial bench; if it forms a thin lamina on sloping banks it may be eroded by subsequent flows. Thus in the last 500 years only six slackwater accumulations have survived at these two lowest sites. These are associated with minimum discharge estimates of 100-200m^3s^{-1}. SWD4, dated at c. 2000 BP, is associated with a discharge estimate of c. 1000m^3s^{-1}; this discharge has been exceeded several times in the last decade. Slackwater deposit 5 is dated at c. 2800 BP by TL and has an associated discharge estimate of c.2600m^3s^{-1}; this is larger than the maximum recorded flood of 1986. Undisturbed mussel shells resting on the upper layer of this deposit are dated at 250±70 BP (ANU 6474). This indicates that the deposit has not been overtopped in the last two or three hundred years. Thus the stratigraphic record suggests that only one flood in the last two thousand years has equalled the 1986 flood, and that only one flood has exceeded it in the last three thousand years (Figure 1).

A Comparison of Gauged Flood Data and the Palaeoflood Record

One approach to the estimation of the magnitude of discharges from very rare floods is to consider the discharge per km^2 of catchment. A recent study by Finlayson and McMahon (1988) provides information on runoff per unit area for catchments in Australia. This is reproduced here as Figure 2. This also provides guidance on the variation between major drainage divisions. Unfortunately these do not include the drainage areas for the north, north-west and central areas of the continent. However Figure 2 does show the envelope curve for the Q100 (discharge for the 1 in 100 year event) for Australia and for 'the largest discharges recorded in the world'; they are approximately coincident. Here it is important to note that the data base used by Finlayson and McMahon is for runs of measured discharge data, ie neither the Australian (37 years) nor world (33 years) data are based on long runs of record.

The maximum discharge estimated from the SWD of Windjana Gorge is 2,600m^3s^{-1}. As discussed above the SWD give discharges that are the minimum flows for the appropriate deposit. The catchment area for the gorge SWD site is estimated to be about 1,200km^2. This gives a discharge per km^2 of some 2.2m^3s^{-1}/km^2. From Figure 2, this is a high discharge per unit area but falls well below both the Australian Q100 and world maximum data.

Pickup et al (1988), from palaeoflood studies of the Finke R. in central Australia, report a slackwater discharge of 5,700m^3s^{-1} for a catchment of 4,500km^2. This is close to 1.3m^3s^{-1}/km^2, and also falls well below the Q100 envelope in Figure 2. Other northern rivers analysed this way are the Katherine Gorge (Q100 = 0.59$m^3s^{-1}km^{-2}$) and the Fitzroy River of WA. (Q100 = 0.65 $m^3s^{-1}km^{-2}$) (Table 1). Thus the Lennard river palaeoflood reconstruction yields an areal discharge that is high by regional standards. From the evidence available, it appears that the palaeoflood estimates available for Australia fall below the unit area discharge values presented by Finlayson & McMahon. It is therefore appropriate to consider the assumptions and

limitations inherent in the palaeoflood methodology.

The first, and likely most significant, is that the SWD provide minimum levels for palaeoflood stage. The maximum water level would be higher, the SWD are essentially deposited from suspended load. For studies where information is available for both maximum water height and for SWD, the discharge is underestimated by some 15-20%. For Windjana Gorge, the increase in stage is likely limited to 2 or 3 metres. It is important to stress again that palaeoflood discharges based on SWD are underestimates.

A second limitation stems from the need to estimate Manning's n. This is basic to the estimation of discharge for whatever modelling procedure is adopted. For extreme floods the depth is such that the dense vegetation bordering the channel is overtopped. This results in a decrease in the roughness coefficient used in the modelling process. At high discharges, removal or flattening of riparian vegetation may further reduce the roughness coefficient. We did not attempt to estimate this additional efffect, and so the palaeodischarge estimates are again likely to be underestimates.

A third possible limitation is the assumption of a stable flood channel. This is certainly valid in the rock-cut reaches of the gorge, but could be in error for the sand sheets within the main channel, which may become mobile beds during floods. This would act to further reduce discharge estimates.

These assumptions and limitations could, in part, explain the apparent low values for palaeoflood discharges in comparison to the results of Finlayson & McMahon. However their results (Figure 2) do not present regional discharge estimates for northern and central Australia. This is due to the paucity of measured discharge data and enhances the usefulness of palaeoflood estimates. It could be that the extreme flood envelope for the Kimberleys is lower than that for the extreme values for continental Australia.

Conclusions

The estimation of extreme flood flows is not only important for fluvial geomorphology but has significance for applied studies that require such information for design purposes. The latter include the design of large dams in hazardous locations (upstream of settlements) and for other structural and nonstructural flood mitigation options that require the estimation of flood discharges close to the magnitude of the probable maximum flood. The limitations of providing such information by statistical extrapolation from short runs of data are well known. This problem is compounded for regions such as northern and central Australia, where there are few gauging stations and records are temporally and spatially sparse. Indeed, most hydrologists would acknowledge that extrapolation from such limited data to obtain estimates for near probable maximum flood conditions results in values with such wide error bands as to be meaningless. Thus there is a growing interest in the contribution to be made by palaeoflood studies, as they can provide an additional and independent technique for the estimation of rare and extreme flow events. This is an application of Quaternary science which is both challenging and relevant to community needs.

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TABLE 1: Discharge estimates for the Lennard River at Mt Herbert (Brown, 1988) and selected northern rivers (this study and Baker & Pickup, 1987)

Lennard River at Mt Herbert

	Area km^2	Q(M^3s^{-1}) Log Pearson	Q(M^3s^{-1}) Gumbel	Q(m^3s^{-1} km^{-2}) Log Pearson	Q(m^3s^{-1} km^{-2}) Gumbel
Q10	439	940	1460	2.1	3.5
Q100	439	1030	2070	2.3	4.7
Q1000	439	1050	2690	2.4	6.1

Discharge estimates for other northern rivers based on slackwater deposits.

	Area km2	Qmax (m3s-1)	Qmax (m3s-1 km-2)
Katherine Gorge	6390	6300	0.99
Finke R.	4500	5700	1.27
Lennard River	1200	2600	2.17
Fitzroy River	45720	29800	0.65

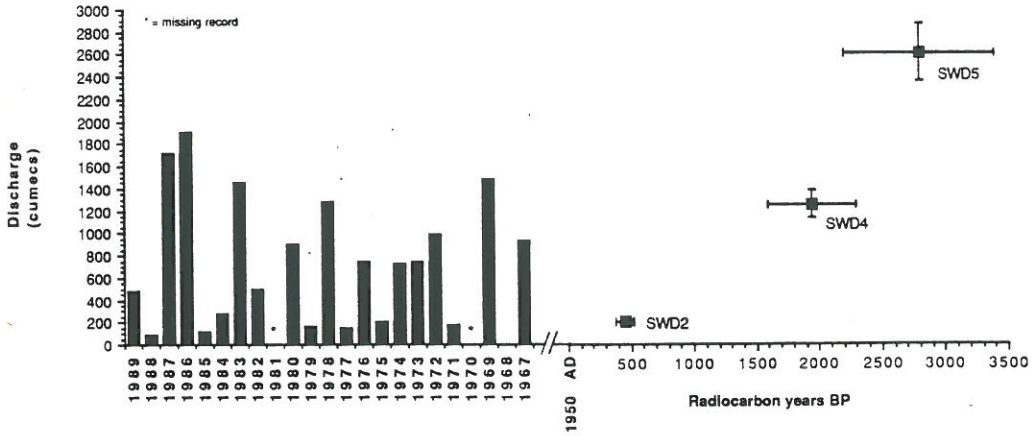

Figure 1: Gauged maximum annual flows (1967-1989) and selected palaeofloods for the Lennard River at Windjana Gorge.

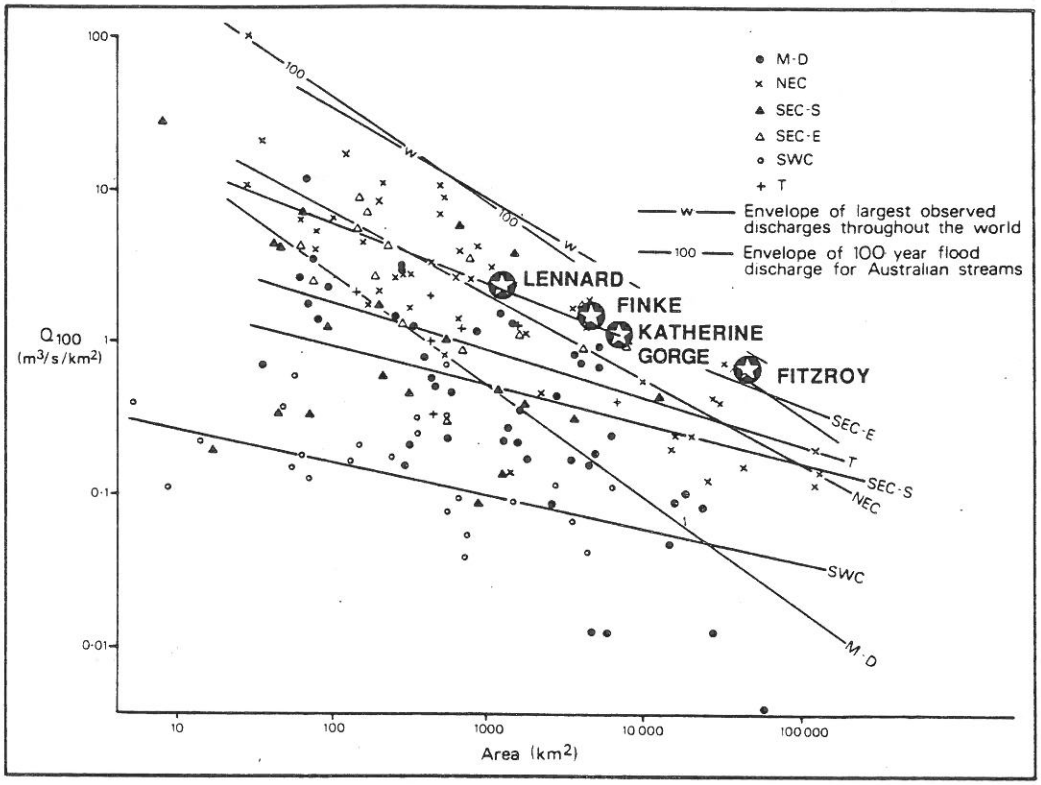

Figure 2: Relationship between Q100 and drainage area for the Australian drainage divisions (reproduced with permission from Finlayson & McMahon, 1988) with selected palaeofloods added.

Abbreviations are: Murray-Darling, M-D; North-East Coast, NEC; South-East Coast (Vic.), SEC-S; South-East Coast in NSW, SEC-E; South-West Coast, SWC; Tasmania, T.

ORIGIN OF SURFICIAL SULPHATE IN THE AUSTRALIAN LANDSCAPE

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The $\delta^{34}S$ values of a variety of gypsum types from the modern playa lakes of southern Australia show little relationship with underlying bedrock types or the $\delta^{34}S$ values of the bedrock sulphur. On a regional scale, in both Western Australia (Yilgarn Block) and South Australia, the $\delta^{34}S$ values of surficial gypsum have a regular pattern over distances of 500 to 1000km with highest values (~+21‰) near coastlines decreasing to $\delta^{34}S$ values of ~14‰ further inland.

Sea-salt sulphate is the dominant source of sulphur to the lakes investigated, although the proportion decreases from ~100% near the coastlines to ~55% in some inland areas. A secondary source of sulphate is also airborne, but derives from volatile biogenic sulphur compounds of largely marine origin. Sulphur derived from rock weathering is a minor component, except in areas where the bedrock contains abundant sulphur. Thus Lake Cadibarrawirracanna receives ~10% of its sulphur from weathering of the pyritic Bulldog Shale (Cretaceous), and Lake Amadeus, possibly up to one-third of its sulphate from evaporites of the Bitter Springs Formation (Late Proterozoic).

Our $\delta^{34}S$ measurements are the first tracers to *directly* establish the marine origin of components in Australian surface brines. The $\delta^{34}S$ analyses indicate the accession of sulphur from both sea-salt and marine biogenic-sulphur and clearly support delivery of salts to the Australian landscape as aerosols following established wind patterns. The data negate the possibility of derivation of the lacustrine "seawater-like" brine chemistry from either marine transgressions or weathering of connate salts from marine strata alone.

The occurrence of non-marine evaporites exhibiting largely marine-like chemistry and isotopic signatures is probably common to low-latitude tectonically stable areas and will make the distinction between marine and non-marine evaporites from the geological record more difficult.

The regular pattern of $\delta^{34}S$ values of surficial sulphate in lakes and groundwaters in southern Australia provides an ideal baseline against which to search for anomalous $\delta^{34}S$ values associated with base-metal or gold mineralization.

(The full text of this paper will shortly appear as: Chivas, A.R., Andrew, A.S., Lyons, W.B., Bird, M.I. and Donnelly, T.H. Isotopic constraints on the origin of salts in Australian playas. 1. Sulphur. *Palaeogeogr., Palaeoclimatol., Palaeoecol.*, 84).

COVER ILLUSTRATION

The figures on the front cover shows a schematic cross-section of the aeolian sand units at Red Point, Illawarra, on the south coast of New South Wales. TL determinations of the ages of aeolian sands and U/Th determinations of the ages of crusts on rock platforms in this region indicate that these techniques give considerable promise of a major advance in deciphering the Pleistocene coastal record in Australia. In this study, the authors claim that the long-standing debate as to whether the +2m level of platforms is modern or is a Pleistocene relict has been resolved for the Illwarra coast, where these platforms can be shown to have formed during the Last Interglacial high stand of the sea. By inference, the +4m level must be of at least the same age. The +6 to 7m level was cut by about 300Ka and may be as old as the Pliocene. Four aeolian units at Red Point reworked from nearby barrier beach complexes date from c. 25Ka, 45Ka, 125Ka, and 300 to >400Ka. From: Bryant, E.A., Young, R.W., Price, D.M. & Short, S.A. 1990. Thermoluminescence and Uranium-Thorium chronologies of Pleistocene coastal landforms of the Illawarra region, New South Wales. *Australian Geographer*, 21, 101-112.