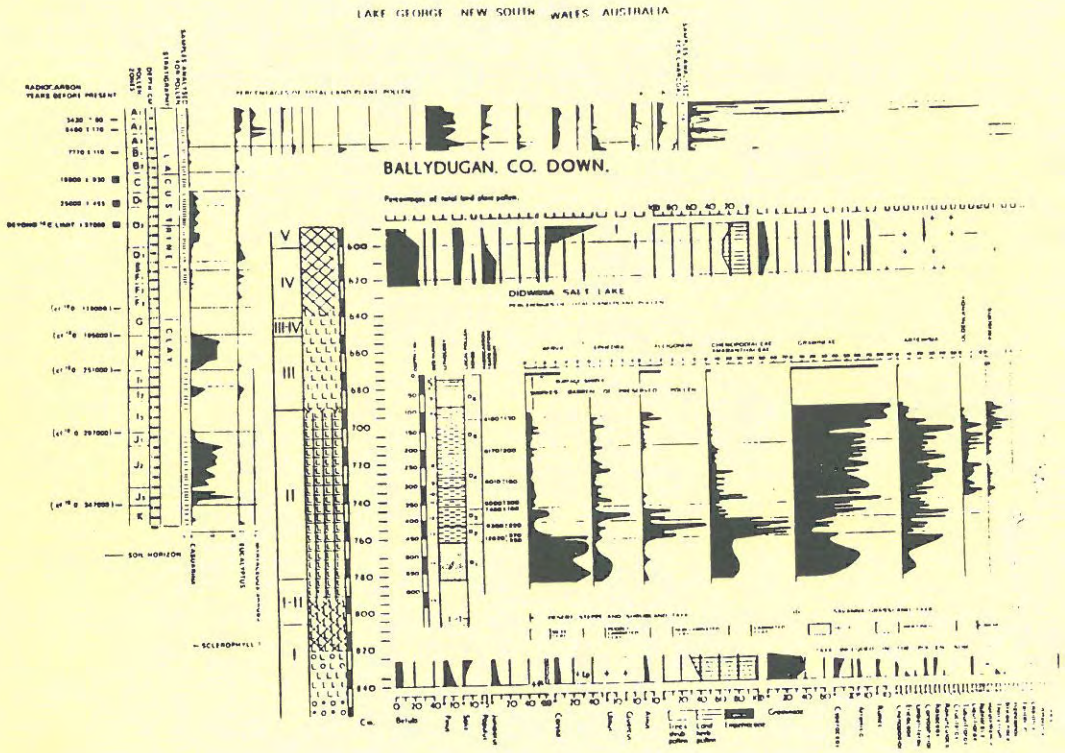
# Quaternary Australasia

*The Newsletter of the Australasian Quaternary Association*




*In memoriam*
Gurdip Singh

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# QUATERNARY AUSTRALASIA, VOL 10/1, MAY 1991

Material for the next issue should reach the editor by **31 August 1992**:

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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 SA20 or $10 for students, unemployed or retired persons. President 1991 - 1993 is Dr Geoff Hope, Department of Biography and Geomorphology, Research School of Pacific Studies, Australian National University, Canberra, A.C.T. 2601. An application form for membership is appended to this issue (last page), and should be returned to Mr. Albert Goede, AQUA, Box 338, Sandy Bay, Tasmania 7005. Members joining after September gain membership for the following year. Existing members will be sent a reminder in December.


## 1991 COMMITTEE MEMBERS

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Archaeology in Oceania


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# EDITORIAL

Welcome to volume 10/2. This volume sees a nice range of papers, from the major paper by Zhou, Williams & Peterson on the E.S.M. examination of sediment grains, through pollen, archaeology and yet more on Diprotodons! As always thanks go the the contributers of both papers and other information contained within these pages, and the referee who commented on this edition's refereed paper. All we now need is copy for the next issue!

Thanks are also due to Martin Williams for drawing my attention to my misuse of Zhou Liping's name in the contents of volume 9/2. Martin also drew my attention to an apparent lack of acknowledgement for the use of the front cover illustration. I normally stick a caption on the back page (outside), but as part of the fun and games involved in editing while I was on study leave last year, the caption appeared on the inside cover of the last page. Martin was, quite rightly, concerned about the potential copyright problems associated with a lack of acknowledgement; copyright resides withe the Geological Society of Australia, and they, of course, should be fully acknowledged as the source of the graphics. We all know about copyright these days, don't we? Just to smooth over any difficulties entirely (overkill??), here is the caption as it appeared, albeit obscurely, in *Quaternary Australasia* volume 9/2:

"The figure on the front cover shows schematic presentations of conditions during successive stages in the Late Quaternary history of Nulchara Lake between Wilcannia and Cobar, Western NSW. Approximate ages for each stage are c. 40 to c. 25 ka for stage 1; c. 25 to c. 20 ka for stage 2; c. 20 to c. 12 ka for stage 3 and c. 12 ka to present for stage 4. This sequence of events is based on detailed field levelling supplemented by five trenches and over twenty deep auger holes. According to the authors of this study, the Late Quaternary history of the gypseous lunette and Nulchara Playa Lake is of special interest because it illustrates, very effectively, certain key features of the desert margin environment of the central-west of NSW, in that i) there are links between the aeolian, fluvial and lacustrine systems throughout this area, ii) that the groundwater system, and especially its seasonal fluctuations, are of importance for activating sediment deflation at the lake margin, and iii) that the conditions of low relief allow integration of these three systems (aeolian, fluvial and lacustrine) within one landscape, a condition not met in many other semi-arid desert margin regions. From Figure 6 in Williams, M.A.J., de Deckker [and not de Dekker, as I seem to have written throughout volume 9/2... more apologies...], P., Adamson, D.A., & Talbot, M.R. 1991. Episodic fluviatile, lacustrine and aeolian sedimentation in a late Quaternary desert margin system, central western New South Wales. pp 258-287, in Williams, M.A.J., de Deckker, P., & Kershaw, A.P. (eds) *The Cainozoic in Australia: a re-apprasial of the evidence. Geological Society of Australia, Special Publication No. 18.*"

***

Elsewhere in this volume, there is a tribute to the late Gurdip Singh from one of his collegues at ANU, our President, Geoff Hope. I am sure that I was not alone in being shocked to hear of Gurdip's untimely death last year. Gurdip's death is a great loss to the Quaternary community in Australia. Many years prior to arriving in Australia, I had corresponded with Gurdip about doing Quaternary research here. He was always most encouraging and helpful, and it was with some pleasure that I was able, some four years after first corresponding with him, that I was able to tell him that I was arriving in Australia. Since being here, he has always been a steadfast source of support, encouragement and critical comment, and I own him my gratitude for this support. He encouraged my research in Central Australia, offering useful advice in my various attempts to ellicit grants to support my research. More recently, I had the pleasure of working at A.N.U. with Gurdip. We had various discussions about his work, starting from his early research in Northern Ireland, where he undertook research very similar to that which I commenced some 20 years later only a few tens of miles away on the southwest coast of Scotland. Gurdip had a strong belief in large-scale, long-term projects, and by the time I visited him, he was obviously taking some delight in seeing the finishing stages of these projects emerging. It is the greatest shame that he will not see these projects to their conclusion, and hopefully, his collegues at A.N.U. will be able to complete them on his behalf. During my time as Gurdip's visitor at A.N.U., I completed the final stages of a pollen flora of South and Central Australia. This piece of work, which stems from my initial introduction to Australian Quaternary pollen analysis in 1986, and encouraged by Gurdip, is a fitting tribute to Gurdip's contribution to building up the incomparable Quaternary palynological facilities within the Department of Biogeography and Geomorphology at A.N.U. I will always regret that Gurdip will not see the final results of my work.

***

On to AQUA matters. Several items of interest are dealt with in this issue. As introduced in my last editoral, AQUA has been, after all these years, stumbling towards becoming incorporated. We now have a constitution. For those of you hardy enough to stomach constitutions, it is reproduced elsewhere in this volme. However, be warned ... this constitution is a gentle one, which should cause little anxiety.

Item 2c in the new constitution draws our attention to one of the objectives on AQUA, *viz.* to convene meetings at regular intervals. In that context, preparations are well under way for the next Inter-INQUA Conference, to be held between 15th and 17th of April next year, in close conjunction with the Sixth International Palaeolimnology Symposium. Elsewhere in this issue, there is a report on progress from Geoff Hope, who has the

unenviable job of organising the organising. It does no harm to repeat Geoff's closing comments in that report: " We need Your Help. Australian Quaternary is on show in this meeting. Choose a theme and contact the convener to offer advice, help and ideas." Need I say more?

***

And finally, the AQUA accounts for 1991 are enclosed within these covers. The keen eyed amongst you will detect that in these days of gloom and doom (anyone seen a resession anywhere?), AQUA seems to be moderately well endowed. There is, however, a simple way in which we can reverse this appalling state of affairs. You will notice that our single largest expense is related to the production of *Quaternary Australasia* (printing, postage and address labels). With even more articles, we could spend even more money, keeping you, the members, informed and entertained. All you have to do is send in more papers, reviews, news and comments. And so, yet again, need I say any more ...?

Bill Boyd,
Editor.



# AUSTRALASIAN QUATERNARY ASSOCIATION CONSTITUTION

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

2. AQUA is a non-profit organisation whose objectives 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 objectives and purposes of AQUA and no portion therof 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 or fellowships in accordance with the object 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 costituted 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.

9. Dissolution shall require a two-thirds majority of AQUA members 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.

# AUSTRALASIAN QUATERNARY ASSOCIATION

## Statement of receipts and payments from 1st January, 1991 to 31 December, 1991.

| | $ | $ | $ |
|---|---|---|---|
| Uncommitted balance brought forward from 1990 | | | 17,692.13 CR |
| Add Receipts | | | |
| Personal subscriptions (1991) | | 2,560.00 | |
| Personal subscriptions (1992) | | 445.00 | |
| Institutional subscriptions (1991) | | 435.05 | |
| Institutional subscriptions (1992) | | 60.00 | |
| Bank, credit union interest | | 2,087.34 | |
| Sale of publications | | 10.00 | |
| Mallacoota Field Meeting | | 649.00 | |
| | | 6,246.39 | |
| Deduct Payments | | | |
| Printing costs | 1,011.53 | | |
| Duties and taxes | 13.22 | | |
| Postage | 417.89 | | |
| AQUA Awards | 1,000.00 | | |
| P.O. Box (Sandy Bay) | 35.00 | | |
| Address labels | 51.20 | | |
| Stationaey | 15.59 | | |
| Dishonoured cheque | 27.00 | | |
| Travel | 175.00 | | |
| | 2,746.43 | 2,746.43 | |
| Excess receipts over payments | | 3,499.96 | 3,499.96CR |
| | | | 21,192.09 CR |

Amounts held in various accounts at 31 December, 1991

| | |
|---|---|
| Westpac cheque account | 526.21 |
| Savings & Loans Credit Union (savings) | 1,414.72 |
| Savings & Loans Credit Union (term deposit) | 19,251.16 |
| | 21,192.09 |

Signed :

A. Goede , Honorary Treasurer, AQUA



# OBITUARY
# GURDIP SINGH

Palaeoecologists and Quaternarists were shocked by the unexpected death of Dr. Gurdip Singh on the 9th November 1991 at the age of 59. Gurdip, a Senior Fellow in the Department of Biogeography and Geomorphology in the Australian National University, was one of Australia's foremost palaeoecologists and recognised for his work on arid zone palynology in India and Australia. His work has always pioneered new fields. For his first Ph.D. (he had one from Lucknow and another from Belfast), he studied the post-glacial history of the Himalaya and later tackled the history of the Rajhastan desert. He developed new methods for analysing desert sediments and made a major contribution to the debate on the relative importance of human disturbance and climatic change on desertification. In 1971 he came to Australia and took up a similar challenge here. His work on Lake Frome and Lake Eyre established that records could be obtained from salt lakes. Not content with routine pollen analyses, Gurdip instituted a network of modern pollen survey stations in southern Australia. He used this work to interpret past changes as movements in summer rain grasslands relative to winter rain saltbush steppe.

Closer to Canberra, Gurdip tackled Lake George, a basin with 80m of clay with only sparse organic remains which had defied previous analyses. A great deal of perserverence was needed to unlock the top 8m to provide the longest terrestrial record currently available, extending back at least 500,000 years. Several glacial - interglacial cycles are revealed, and this is one of the few sites to contribute to the debate about the influence of fire on the Australian flora, since the present interglacial is not matched by others down core, which have greater levels of ferns and *Casuarina* and lower levels of eucalypts and charcoal. Whether the site gives evidence of early human impact, as Gurdip suggested, remains to be seen, but it is of major importance in understanding the appearance of the modern communities. TL may well contribute to resolving the problematic dating.

Not content with the sparsely-organic clays of Lake George, Gurdip tackled materials from Lake Eyre and Lake Frome and achieved a major success with his Late Glacial and Holocene record from Lake Frome. He made the novel suggestion that grass-to-chenopod (saltbush) ratios might indicate summer/winter rain balances, and proceeded to develop a hypothesis that the early Holocene may indeed have been a time with greater summer rain incursions into central Australia. He was a valued contributor to the SLEADS activities over the years. Work correlating modern pollen with source vegetation across southeastern Australia will be prepared for publication by Peter Minchin.

At the time of his death, Gurdip's major project was to finish the fine resolution analysis of Bega Swamp, a montane grassy mire near Nimitabel, N.S.W.. This is the most detailed vegetation history yet attempted in Australia, with sample intervals of less than 10 years. He intended to tackle the long term consequences of individual fire events and vegetation dynamics, thus building a bridge between the unfortunately vague vegetation historians and the vegetation dynamicists and modellers for whom 100 years represents a major piece of time. The straightforward work on this site will be completed, but we cannot replace the insights and imagination that Gurdip would have brought to the interpretation of this complex problem. Gurdip was very pleased that the Bega Swamp area was made a reserve, and now it is to be incorporated into Wadbillaga National Park.

Gurdip has given us original ideas which quite often were ahead of the evidence. His statement of them was always scrupulous and the possibilities embodied by them illuminated his work and added greatly to general thinking about Quaternary histories and processes. He was a generous and big-hearted person whose breadth of experience and learning cannot be replaced.

Geoff Hope
Department of Biogeography & Geomorphology, Research School of Pacific Studies, Australian National University.

# Inter-INQUA CONFERENCE

# 6TH INTERNATIONAL PALAEOLIMNOLOGY SYMPOSIUM

# PROGRESS REPORT

**Inter-INQUA: 16 - 18 April 1993**

**6th International Palaeolimnology Symposium: 19 - 21 April 1993**

The above conferences are going to run as separate but co-ordinated operations in the week after Easter, next year. They will be held on campus at the Australian National University in Canberra, with joint excursions and other functions. Partick DeDeckker, John Magee and Alan Chivas are organising the 6th Palaeolimnology Symposium which has a theme of tropical lakes and rivers. The Inter-INQUA organising committee is:

| | Phone | FAX |
|---|---|---|
| Paul Bishop (Monash) | | |
| | 03 565 4617 | 03 565 2948 |
| Doreen Bowdery (ANU) Secretary | | |
| | 06 249 0585 | 06 249 2711 |
| John Dodson (UNSW) | | |
| | 02 697 4390 | 02 313 7878 |
| Tim Flannery (Aust. Museum) | | |
| | 02 339 8114 | 02 360 4350 |
| Dave Gillieson (NSW-ADFA) Program Coord. | | |
| | 06 2688305 | 06 268 8313 |
| John Grinrod (Monash) Publicity | | |
| | 03 565 4621 | 03 565 2948 |
| Jay Hall (UQ) Convener Theme 2 | | |
| | 07 365 3235 | 07 365 1544 |
| Geoff Hope (ANU) Organiser | | |
| | 06 249 3283 | 06 257 1893 |
| Peter Kershaw (Monash) | | |
| | 03 565 2927 | 03 565 2948 |
| Brian Lees (ANU) Excursions | | |
| | 06 2493795 | 06 249 3770 |
| John Luly (ANU) | | |
| | 06 249 2611 | 06 249 3770 |
| Colin Murray-Wallace (U.N'castle) Convener Theme 1 | 049 215 415 | 049 216 925 |
| Ted Bryant (Wollongong) Convener Theme 3 | | |
| | 042 213 685 | 042 213 764 |
| Liz Truswell (BMR) Publications | | |
| | 06 249 9427 | 06 257 3667 |
| Karl Wyrwoll (W.A.) | | |
| | 09 380 2714 | 09 380 1054 |

## THEMES

The conference will run over three days with three themes as separate streams that will be integrated in major sessions and by emphasising poster papers. The three themes are:

THEME 1: *Marine and terrestrial records: Do they agree?*

THEME 2: *Environments for humans in Australia and human impact on environment.*

THEME 3: *Climatic change and landscape response.*

These themes will incorporate the INQUA current concerns under IGBP, PAGES, PANASH and the other acronyms of Quaternary activity.

## TIMETABLE

APRIL 1993

| M | T | W | T | F | S | S |
|---|---|---|---|---|---|---|
| | | | 8 | 9 | 10 | 11 |
| | | | <--- EXCURSIONS-PRE - | | | |
| | | | | | <----- Easter ------- | |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| ----------> | | | <- Inter-INQUA -> | | | |
| ------> | <------ Aust. Univ. common week ------> | | | | | |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| <- PALAEOLIMNOLOGY -> | | | | <--- EXCURSIONS- | | |
| 26 | 27 | 28 | 29 | 30 | | |
| POST ----------> | | | | | | |

## PLANNING

The First Circular (call for papers and interest) should appear at the end of April and the second (Main program and Registration) is planned to come out in October. The conference is expected to attract 200 people and will have to be a bit more formal than an AQUA conference. We have appointed a commercial organising firm to help:

Australian Convention and Travel Services (ACTS), Box 2200, Canberra, ACT, Australia 2601. Tel.: 61 (0)6 257 3299; FAX: 61 (0)6 257 3256

The budget is still being worked out, but registration should be about $150 for AQUA members and $70 for students, plus a bit more if you attend both conferences.

The First Circular will be sent to all AQUA members; others should write to Geoff Hope or ACTS for details.

## EXCURSIONS

We are still considering a wide range of excursions which are open to attendees at either conference. A limited number can go out to Lake Eyre before the meetings while others can travel from Melbourne to Canberra via western Victoria and Mungo. A separate trip to Mungo may take place if needed. Day excursions in the Canberra area and Mt Kosciusko will keep jaded brains sharp, and those returning to Sydney will have the option of being educated over two days by the Wollongong mob via Shoalhaven and the coast. Real stayers can keep on up to Newcastle and the Myall Lakes, or flit to north Queensland to see Atherton and more northern Quaternary sites. And of course New Guinea (Irian Jaya) can be arranged for those passing through Bali. No doubt some of these trips will lapse.

**We need Your Help!**

Australian Quaternary is on show in this meeting. Choose a theme and contact the convener to offer advice, help and ideas.



# CONFERENCE AND MEETING NEWS

5-9 July 1992 **International Symposium 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-Pierre Suc, Secretary 8th IPC Laboratoire de Palynologie (case 061), Univ. de Montpellier II, F-34095 Montpellier cedex 5, France.

18-22 January 1993. **Southern Temperate Ecosystems: Origin and Diversification**, Hobart. Contact Bob Hill, Dept Plant Science, University of Tasmania, Box 252C, Hobart, 7000, Australia.

29 March - 2 April 1993. **4th International Conference on Southern Hemisphere Meteorology**, Hobart, Tasmania. Contact Dr. David Karoly, Co-convener, 4ICSHMO, Centre for Dynamical Meteorlogy, Monash University, Clayton, Victoria 3168, Australia.

16-18 April 1993. **Inter-INQUA Conference - The Australian Region in the Quaternary.** Contact Geoff Hope, Biogeography and Geomorphology Dept, ANU, Canberra, Box 4 Canberrra, 2601, Australia.

19-21 April 1993 **Sixth International Paleolimnology Conferece**, Canberra. Contact Patrick De Dekker, Geology Dept ANU, Canberra, Box 4 Canberrra, 2601, Australia.

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.

22-25 April 1993. **Fifth Meeting of the Australian New Zealand Geomorphology Research Group**, Port

Macquarie, NSW. Contact Gary Brierly, Biogeography and Geomorphology Dept, ANU, Canberra, Box 4 Canberrra, 2601, Australia.

5-9 July 1993. **5th International Conference on Fluvial Sedimentology**, Brisbane, Australia. Contact Continuing Professional Education, The University of Queensland, Queensland 4072, Australia.

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

Adamson, D.A. & Darragh, A. 1991. Field evidence on Cainozoic history and landforms in the northern Prince Charles Mountains, East Antarctica. pp 5-14 in Gillieson, D. & Fitzsimmons, S. (eds) 1991. *Quaternary research in Australian Antarctica: Future directions*. Special Publication No 3, Department of Geography & Oceanography, University College, University of New South Wales, Australian Defence Force Academy, Canberra.

Bairstow, D. 1991. Urban archaeology: American theory, Australian practice. *Australian Archaeology*, 33, 52-58.

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Barker, B.C. 1991. Nara Inlet 1: Coastal resource use and the Holocene marine transgression in the Witsunday Islands, central Queensland. *Archaeology in Oceania*, 26(3) 102-109.

Berger, A. & Loutre, M.F. 1991. Insolation values for the climate of the last 10 million years. *Quaternary Science Reviews*, 10(4), 297-318.

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Bowdler, S., Strawbridge, L & Schwede, M. 1991. Archaeological mitigation in the Perth metropolitan region. *Australian Archaeology*, 32, 21-25.

Brown, S., Kee, S., McGowan, A., Middleton, G., Nash, M., Prince, B., Ricketts, N. &West, D. 1991. A preliminary survey for Aboriginal sites in the Denison River Valley, March 1989. *Australian Archaeology*, 32, 26-37.

Chappell, J. 1991. Late Quaternary environmental changes in Eastern and Central Australia, and their climatic interpretation. pp.377-390 in Thom, B.G. & Wasson, R.J. (eds) 1991. *Quaternary studies in Australia and New Zealand. Quaternary Science Reviews*, 10 (5).

Colhoun, E.A. & Adamson, D.A. 1991. Raised beaches of the Bunger Hills, Antarctica. pp 79-84 in Gillieson, D. & Fitzsimmons, S. (eds) 1991. *Quaternary research in Australian Antarctica: Future directions*. Special Publication No 3, Department of Geography & Oceanography, University College, University of New South Wales, Australian Defence Force Academy, Canberra.

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Cronin, T.M. & Dowsett, H.J. (eds) 1991. *Pliocene Climates. Quaternary Science Reviews*, 10(2/3).

DeDeckker, P., Kiss, E. & Chivas, A.R. 1991. The suitability of lakes on the Windmill Islands in Antarctica for palaeoloimnological studies. pp 69-78 in Gillieson, D. & Fitzsimmons, S. (eds) 1991. *Quaternary research in Australian Antarctica: Future directions*. Special Publication No 3, Department of Geography & Oceanography, University College, University of New South Wales, Australian Defence Force Academy, Canberra.

Derbyshire, E. (ed.) 1991. *Quaternary environmnets in China. Quaternary Science Reviews*, 10(6), 479-554.

Dortch, C.E. 1991. Rottnest and Garden Island prehistory and the archaeological potential of the adjacent continental shelf, Western Australia. *Australian Archaeology*, 33, 38-43.

du Cross, H. & Rhodes, D. 1991. Commonwealth/Telecom sites: Artefact cataloguing and analysis methods. *Australian Archaeology*, 32, 17-20.

Egloff, B.J., Paton, R & Walkington, M. 1991. Finger Point archaeological project: A brief report. *Australian Archaeology*, 33, 28-37.

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## Bibliography of Australian terrestrial fossil mammals on computer data base

The mammal bibliographic reference list and the genus by genus fossil mammal literature reference appendix in Vickers-Rich *et al.* (1991) *Vertebrate Palaeontology of Australasia* have been combined by Alex Baynes to form an integrated computer data base. Copies are available free on condition that all recipients (including those who receive copies from third parties) undertake to document and attempt to correct errors or omissions that they detect in the data base, and register their copy with Alex Baynes. (Registration is mainly for the benefit of the recipients as it will enable them to receive notice of improved versions in future). A Macintosh version is available from Dr Alex Baynes, Department of Earth Sciences, W.A. Museum, Francis St, Perth, Western Australia 6000, and an Ms-DOS version from Greg McNamara, Geology Dept, James Cook University, Townsville, Queensland 4811. To obtain a copy of the data base complete a photocopy of the form below and send it and a formatted floppy disk and **return postage** and packing to Alex for the Mac version, or to Greg for the Ms-DOS version (Greg will pass on the registration forms to Alex). A new Jiffy bag used for the empty disk will usually be in good enough condition to return the loaded disk. We can cope with all kinds of floppy disks.

The computer data base consists primarily of an alphabetical bibliographic listing in which each record is composed of 14 fields, containing author, date, title, publication, volume and page numbers, mammalian genera (as keyword fields) and remarks. This is supported by two supplementary data bases which provide a guide to the nomenclature of Australian mammal genera and (for Mac only) a simple means of generating a generic listing from a reference. There is also a word processor document providing instructions on the use of the data bases. The files were created on Macintosh using Microsoft Works 2.00a, and their combined size is currently about 300K. In addition to MsWorks format the Mac files can be made available as text [ASCII], with the data base fields separated by tabs (the Macintosh standard), for use with other software (including version 1 of Works which takes less RAM); or with field separators other than tabs (please specify). The MsDOS version is available as ASCII delimited (default: fields separated by commas; other delimiter e.g. tilde (~) should be specified); ASCII fixed field; dBase; RBase; Lotus 1-2-3; or Symphony formats. Technical details of your computer should be completed in the form below so that appropriate versions of the files can be supplied. The Mac data base will run in version 2.00a of MsWorks on a 1 Mb Mac Plus with an 800K external disk drive and no hard disk, but it requires a specially slim version of System 6, which Alex can provide upon request and provision of a double-sided (800K) disk. If you have a Mac 512 / 800 and access to a copy of Works 1.0 don't despair, the bibliographic data base can probably be broken down into smaller units, but make sure you provide Alex with full details of your computer. (128K or 512 / 400 Mac owners will have to make do with the book, sorry.)

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QUATERNARY AUSTRALASIA PAPERS
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# SURFACE MICROTEXTURE STUDY OF LATE QUATERNARY AEOLIANITE BY SCANNING ELECTRON MICROSCOPY AND ITS IMPLICATION FOR RECONSTRUCTING THE SEDIMENTARY ENVIRONMENT: A CASE STUDY FROM FINGAL BEACH COAST CLIFF SECTION, CAPE SCHANCK, VICTORIA

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## Abstract

Fingal Beach coastal cliff section is a forty-five metre thick aeolianite section near Cape Schanck, Victoria. Twenty-four samples collected from the section were examined by Scanning Electron Microscope. Preliminary results show that the aeolianite sediments have undergone a number of different sedimentary processes including aeolian transportation, subaqueous modification, weathering, pedogenesis, and cementation.

## Introduction

During his study of calcareous sandstone situated over 800 metres above sea level in Bermuda in 1929, Sayles defined "aeolianite" as "all consolidated sedimentary rocks which have been deposited by wind" (Sayles, 1931). This term normally refers to wind blown materials of all sizes which have been cemented, either subaerially or after burial, by calcium carbonate, iron oxides, silica, gypsum or other materials(Gardner, 1983). However, most later workers have limited the term to calcium carbonate cemented wind blown materials.

The global distribution of aeolianite coincides with present-day climates ranging from arid to Mediterranean, subtropical and tropical. Aeolianite occurs around the Mediterranean, the Arabian peninsula, India, South China, Central America, Hawaii, southern Africa, western South America and Australia. In Australia, aeolianites are distributed from the west coast of Western Australia to Wilson's Promontory in southeastern Victoria.

The geological structure of the Mornington peninsula in which Cape Schanck is located is complex (Figure 1). The Selwyn Fault crosses the region from north to south, cutting the area into two parts - the older eastern part of pre-Pleistocene age and the younger western part of Late Quaternary age. Located in the southern part of the Mornington peninsula and west of the fault, Nepean Bay Bar is largely composed of Quaternary aeolianite. Aeolianite in the region can often reach as high as 20 - 45m above present sea level. A full account of the ages and Quaternary history of these aeolianites will appear in a separate paper.

The microtextural analysis of sand grain surfaces has long been regarded as an important indicator of the environment through which a sediment has passed (Marsland and Woodruff, 1937; Bond, 1954). The study of quartz grain surface textures became common once Scanning Electron Microscopy (SEM) became widely available. An estimated 1000 publications concerning environmental reconstruction by SEM have been published so far, but SEM studies of aeolianite surface microtextures and their environmental implications are rare, and to our knowledge have never been applied to coastal aeolianites in this region.

## Sampling and Laboratory Techniques

To take samples from the cliff sections, the surface layers of the sections were carefully scraped clean and about 50g of sand was gently removed and placed into plastic bottles marked with identification numbers. Twenty-four samples were taken from sixteen different stratigraphic units (Figure 2) for Scanning Electron Microscopy analysis in the laboratory. The whole process was carried out very carefully to minimise damage to the surface microtextures of the sediments.

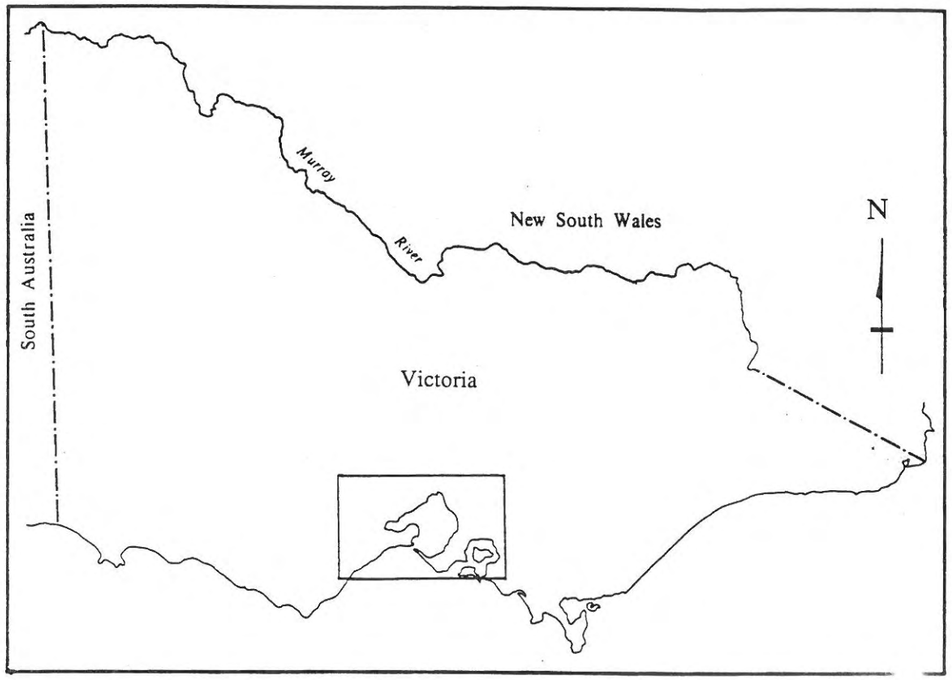






Figure 1. Location and Geological Map of Nepean and Southern Mornington Peninsulas (After E.C.F. Bird, 1982)



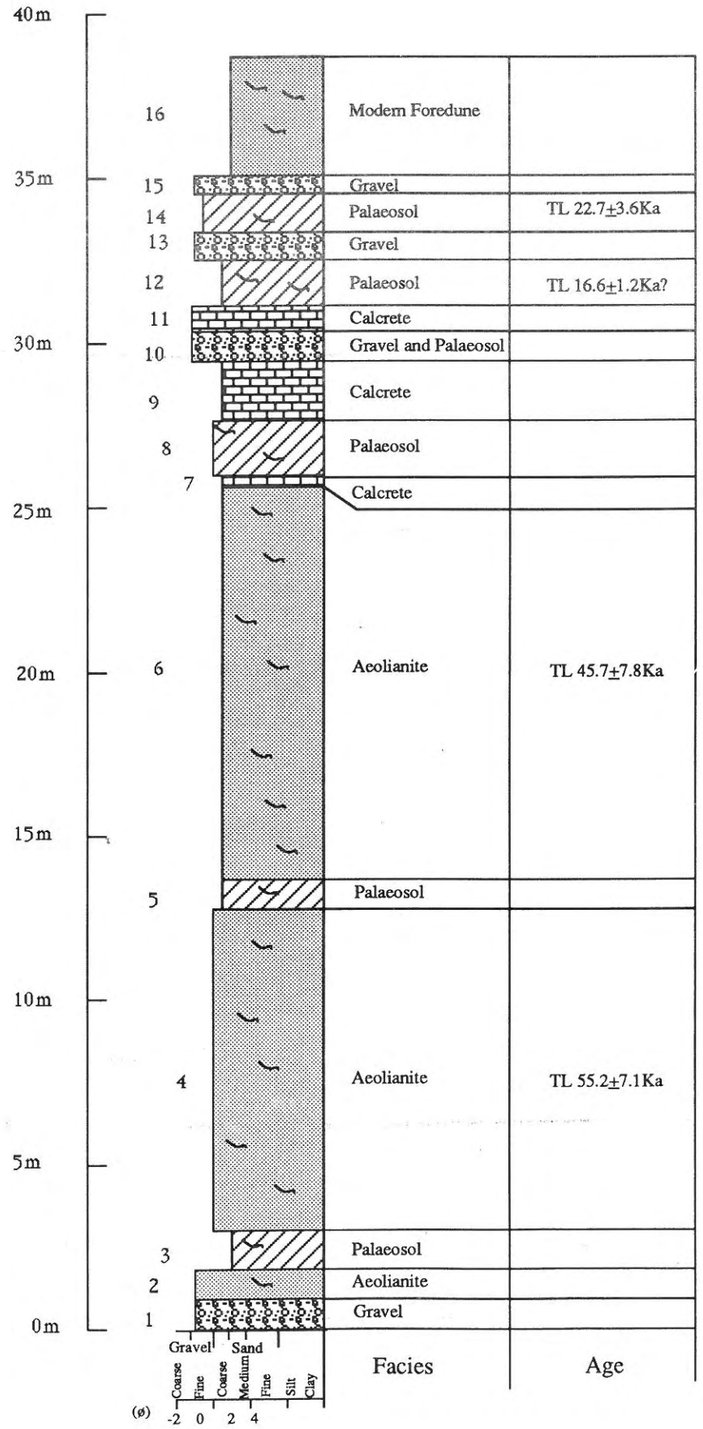



Figure 2. A Log Diagram of Stratigraphic Section from Fingal Beach Coastal Cliff, Cape Schanck, Victoria

The following procedure is the laboratory preparation of the samples for SEM analysis. Since SEM operates under high vacuum and high voltage, the specimen must make good electrical contact with the support ( usually an aluminium stub).

Depending on the kind of analysis, two different techniques were used in the preparation of each sample. Each sample was divided into two parts, one for surface microtexture study and the other for calcium carbonate cement study. To prepare the specimen for surface microtexture analysis, samples were treated following the method described by Krinsley and Doornkamp (1973). About 15g of aeolianite were removed from each original sample. These samples were then placed in 10% hydrochloric acid to remove all calcium carbonate materials. The samples were washed with distilled water several times until effective scene ceased. They were then boiled in a stannous chloride solution for 30 minutes to remove iron oxide, and washed with distilled water. Organic debris was removed with a strong oxidising solution of 1.5g each of potassium dichromate and potassium permanganate dissolved in 15ml of concentrated sulfuric acid (McIntyre and Be, 1967). The grains were washed again and finally dried in a low temperature oven (less then $60^0$C to suit the vacuum environment). This procedure is necessary because the sand grains must be absolutely clean. The samples were finally sieved using 0ø and 2ø sieves to select certain sizes of specimen for analysis. For the cementation study, the samples only needed to be dried and then mounted on the stubs.

Having prepared a satisfactory surface of the specimen, the next step was mounting. To mount the samples on the metal stubs, approximately 30 to 45 quartz grains from each sample were chosen at random. The well dispersed sand grains were stuck to a stub with double-sided adhesive tape. Coating of our samples for SEM was done by sputter coating. Platinum was used as the sputtering material because it has the advantage of fine grain size if high-resolution studies are to be attempted. The equipment is an EIKO IB-5 sputter coating unit. In the unit, specimen stubs are placed into the chamber. High vacuum of 0.1 Torr or lower is obtained by vacuum pump. The platinum is then evaporated in the nitrogen environment.

## Surface Microtextures of Aeolianites

Under SEM, the mounted and coated aeolianite sand grains were first viewed at lower magnification to characterise the gross surface features (50x to 100x). Individual grains were then viewed at various higher magnifications (300x to 10,000x) to observe surface micro features. Seventy per cent of observed grains were finally photographed for analysis. Different magnifications were used to view the samples because this revealed the different types of surface texture. Microtextures potentially diagnostic of glacial, aeolian, subaqueous and high energy environments were observed at various magnifications. The roundness, sphericity and shapes may be recognised at low magnification while specific areas needed to be examined and photographed at a magnification of between several hundred and several thousand. It is not difficult to find very sharp edges which may refer to glacial evidence at 100 to 200x, but the determination of surface microtextures of aeolian action requires magnification of between 2000 and 10,000x. In some cases, it was necessary to review the upturned plate at up to 30,000 magnification to identify the effects of solution.

*Composition and Original Faces of Sediments under SEM* (Plate 1)

Nearly all of the specimens examined by SEM have a similar composition. Quartz sand grains comprise the major proportion of the aeolianites. The quartz grains typically show conchoidal fracture (Plate 2). Carbonate sands in different shapes and forms, such as sands and shells, are a very important part of the aeolianites. Aeolianite sands are normally cemented by calcium carbonate.



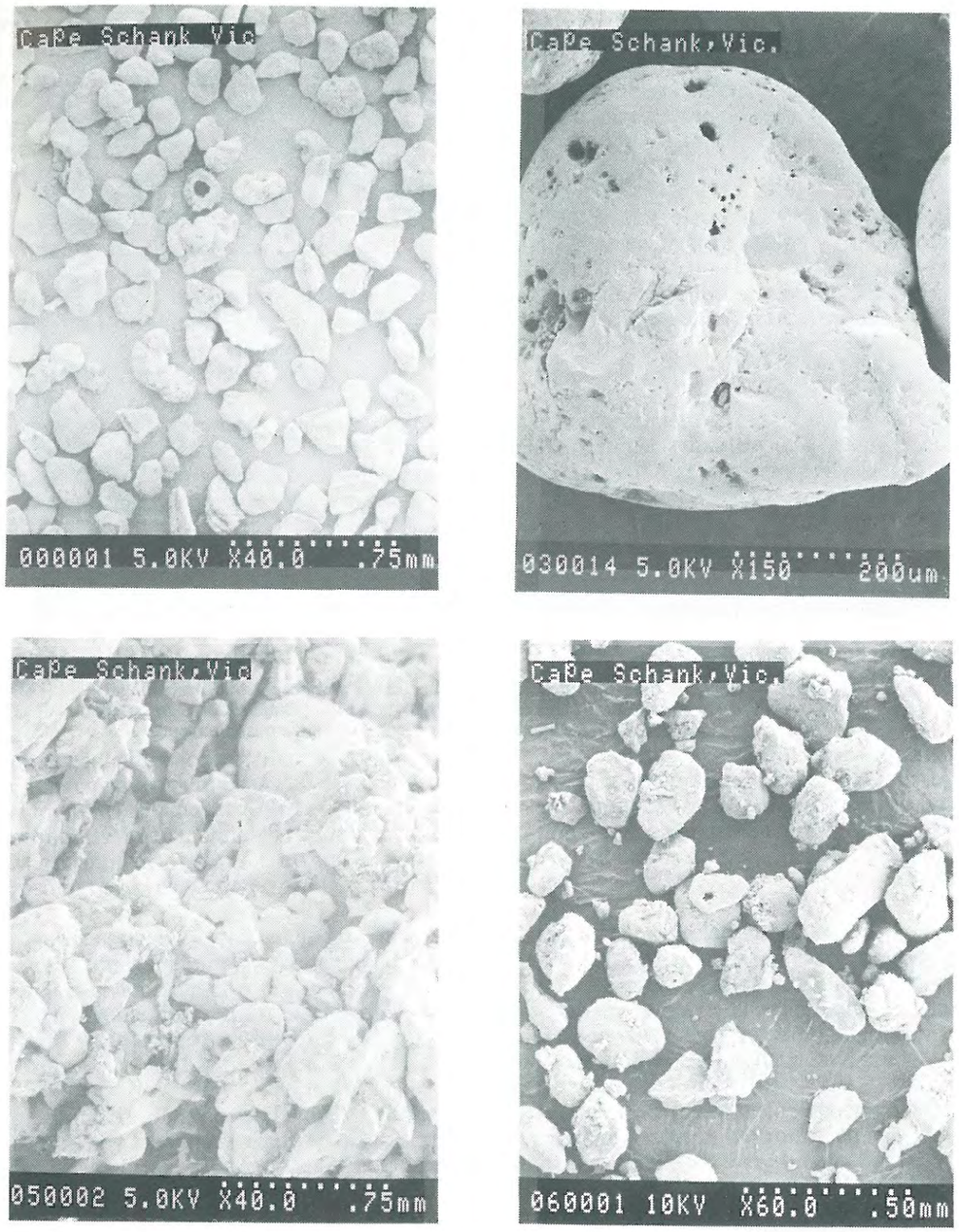



PLATE 1: Composition and natural faces of the sediments. Top left: Platform sands, showing the angular shapes of the sand grains, consisting of quartz, carbonate sand, shells and other minerals. Top right: Beach quartz sand. Bottom left: Aeolianites, cemented by calcium carbonate materials. Bottom right: Palaeosols have small particles adhering to grains.

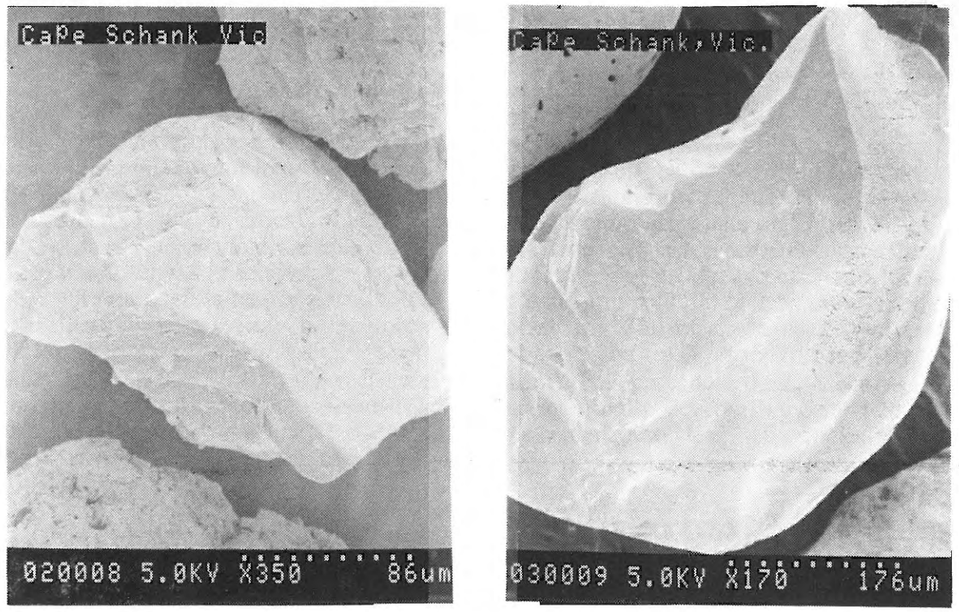



PLATE 2: Conchoidal breakage of quartz sand; aeolianite and beach sand from Fingal Beach, Cape Schanck. Note that the newly exposed breakages of conchoidal surface are the diagnostic evidence for the quartz mineral.



*Shapes and Roundness*

Many grains of aeolianite show rounded or well rounded features (Plate 3), and spherical shapes are common. Some grains were elongated, but with rounded edges. The rounding of the sand grains can also reflect an aeolian environment. These samples were not found to be as well rounded as typical desert grains, perhaps because they have spent considerable time in a littoral environment rather than an aeolian environment. The degree of rounding on large aeolian grains depends on wind intensity and length of time in the aeolian environment (Krinsley and Doornkamp, 1973).

The textures of fresh angular, razor sharp edges and corners which may imply a typical glacial environment or source material are rarely seen among these sand grains. Among the seven hundred grains examined under SEM, only a few quartz grains had this feature. They did not appear as fresh fractures, but had been modified by later weathering and diagenesis. This may indicate that the sand grains were not of local origin, or were perhaps modified local sediments.

*Mechanically and Chemically V-shaped Forms*

Among all the microtextures on the studied samples, the most frequently found features are V-shaped patterns or depressions. These V-shapes and depressions can normally be observed under magnifications of between 1000x and 3500x. According to the statistics of Krinsley and Doornkamp (1973), these depressions range in surface density from one to more than six V's per $um^2$.

These V-shaped depressions can be created by two different environmental media, mechanical and chemical activity, and show two kinds of depression, oriented and non-oriented V-forms. V-shaped mechanical depressions are three sided and narrow towards the grain surface. They are chipped into surface expressions of the underlying plate edges which are essentially the weakest points on the surface. The oriented V-forms (Plate 4) normally have regular outer edges. They are probably controlled by crystallographic axes in the grain (Krinsley and Donahue, 1968).

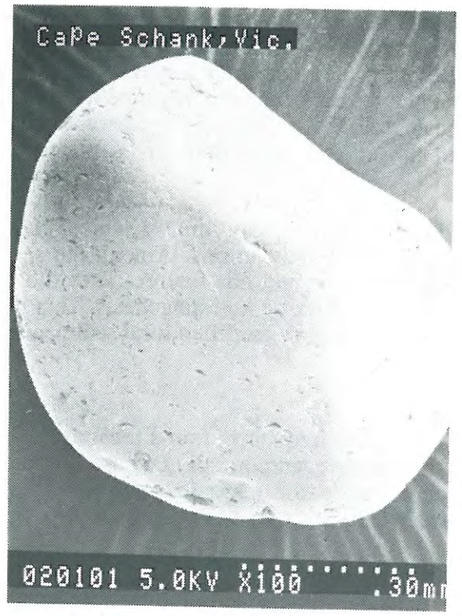
The mechanically non-oriented (Plate 5) indentation was probably caused by grain-to-grain collisions in aqueous media. This texture was first recognised and reproduced experimentally by Krinsley and Takahashi (1962). The angle between the arms of the V-shaped patterns has subsequently been studied both on natural beach grains and on experimental grains. The skewness and kurtosis of the natural and artificial angle distributions do not differ significantly, suggesting that both were formed in the same way.

The causes of the non-oriented and oriented V-forms may have some relationship. In low-energy beaches, chemical etching may be the dominant factor. When wave energy increases, randomly oriented V-shaped patterns replace the V-shaped etched features. Grain to grain collision occurs and creates some linear grooves. Other linear grooves are made by a second or third collision, and together with the former show as V-forms on the sand grain surface. It is for this reason that mechanically formed V-forms can easily be found with linear grooves on the same sand grain.

Large numbers of grooves (Plate 6) can also be found on sand grain surfaces from all the samples. They have no definite shape or size. Their length can normally be from 1um to 10um. Under SEM, some grain surfaces still appeared to be fairly smooth, but were broken by the V-shaped depressions and grooves. Some had parabolic or triangular shapes. The distribution pattern of grooves was random. They were frequently found either along cleavage plates or across the plate at any angle. The grooves generally appeared together with non-oriented V-shaped patterns. These depressions are regarded as the products of a subaqueous high-energy environment (Krinsley and Doornkamp, 1973). Their size and density of distribution on the sand grain surface may reflect the energy scale.

*Solution and Deposition Features*

The characteristics of solution and redeposition are commonly found in these sand grains (Plate 7). This leads to diagnostic complexity because this feature can occur within all



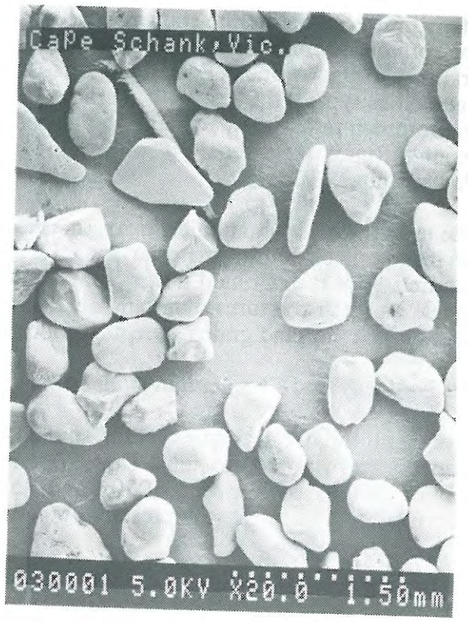
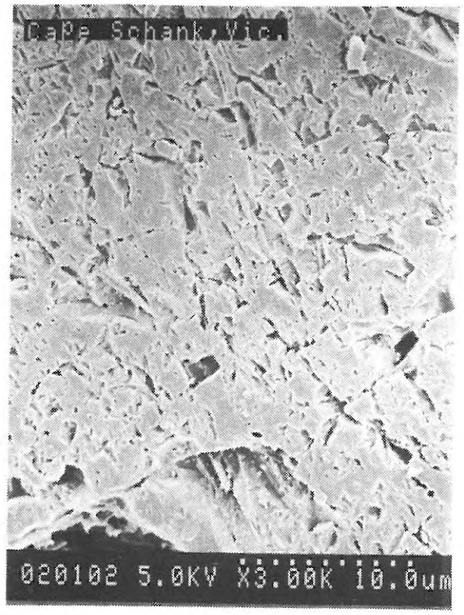



PLATE 3: Shapes and roundness; aeolianite, beach sand and palaeosol from Fingal Beach, Cape Schanck. Top left: Aeolianite, showing the very well rounded quartz grains with small indentations on the smooth surfaces. Top right: Beach sands, with most being rounded, or having unsharpened corners or edges. Bottom left: Palaeosols, showing well-rounded a quartz grain with some cracks on its surface.

PLATE 4: Orientated V-shaped forms: aeolianites from Fingal Beach, Cape Schanck. Aeolianites, from lower (left) and upper (right) locations of the cliff section, showing the oriented chemically-etched indentation and small non-oeriented indentation.

PLATE 5: Non-oriented V-shaped forms; aeolianites from Fingal Beach, Cape Schanck. Both specimens, from the lower (left) and upper (right) locations on the cliff section, show the non-oriented V-shaped forms at different scales.



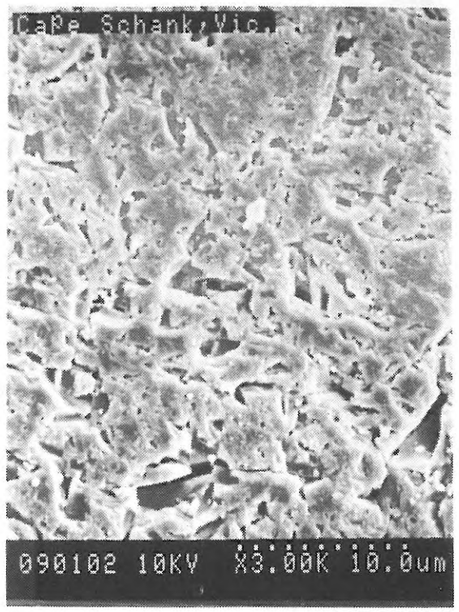




PLATE 6: Linear grooves and blocked breakages; palaeosols and superficial dune sand from Fingal Beach, Cape Schanck. The linear grooves on the palaeosol sand grains (left) may be created by many small V-shaped forms, and the block breakages (right) were probably produced by several linear grooves.

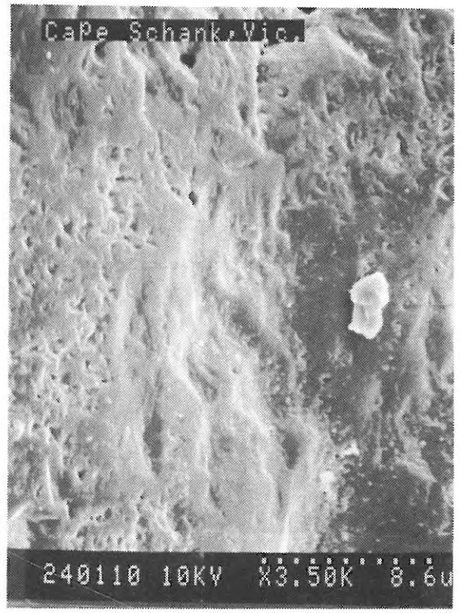



PLATE 7: Solution and deposition; palaeosol and modern soil from Fingal Beach, Cape Schanck. Both the palaeosol from the middle of the cliff section (left) and the modern soil from the top (right) are subjected to solution and deposition. These two processes combined to smooth the grain surface.



environments(Plate 4). Solution and precipitation are different aspects of the same mechanism. Under both activities, the sand grains may become smoother than in the previous state. Solution often occurs on the upturned plate to lower the relief, while precipitation happens on the lower area to fill up the depressions (Krinsley and Doornkamp, 1973). The silica used in precipitation usually comes from solution, so there is a possible dynamic equilibrium between precipitation and solution.

*Upturned Plates*

Upturned plates (Plate 8) can be found on some sand grain surfaces. These plates ranged from 0.5um to about 10um with depressions between them. They had no definite size or shape, but the ridges were always nearly parallel. The relation between grain size and feature length is unknown, but Krinsley and McCoy suggested that the length of plates increases as grain sizes become larger (Krinsley and McCoy, 1978). On the sand grain surface, the upturned plate shows an assemblage pattern of disconnected plates. These plates are considered diagnostic features of an aeolian environment. They apparently result from conchoidal breakage by collision when the sand moves in the air (Krinsley, *et al*, 1976). These features can also appear in littoral sand grains, but much less frequently than in aeolian grains, because wind transported sand may have kinetic energy several hundred times greater than sand moved by water (Bagnold, 1941). This feature did not appear very frequently and was mostly modified by subsequent littoral action which may suggest that the aeolian action happened prior to the littoral one, or that aeolian and littoral processes operated episodically and in alteration.

*Calcium Carbonate Cements*

Two kinds of carbonate cement were found under SEM (Plate 9): aragonite cements and high-Mg calcite cements. The most common cement in the aeolianites and palaeosols studied are aragonite needles (Plate 9b). They are elongate and pointed, or display broader, lath-like shapes. The aragonite crystals commonly form the rims with similar thickness around the grains, thus implying cementation in water-filed pores of a marine-phreatic diagenetic environment. Marine-phreatic aragonite cements were found in all of the samples studied.

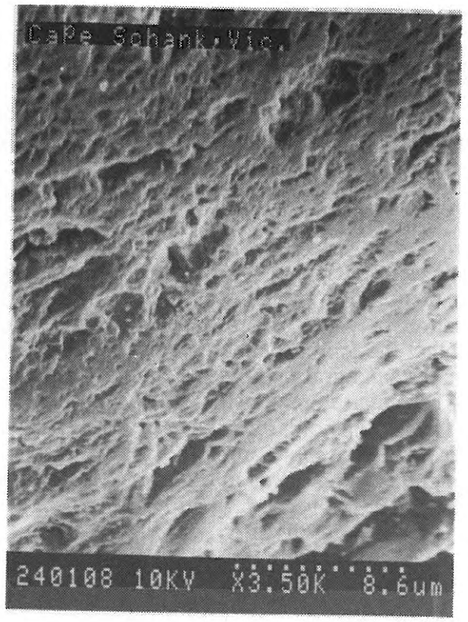
Some samples contain high-Mg calcite (9c) displaying scalenohedral crystal forms. High-Mg calcite occurs together with aragonite, either growing between the needles and platelets, or replacing them laterally. The magnesium-rich calcite cements display an isopachous disposition and indicate a marine-phreatic environment (Longman, 1980).

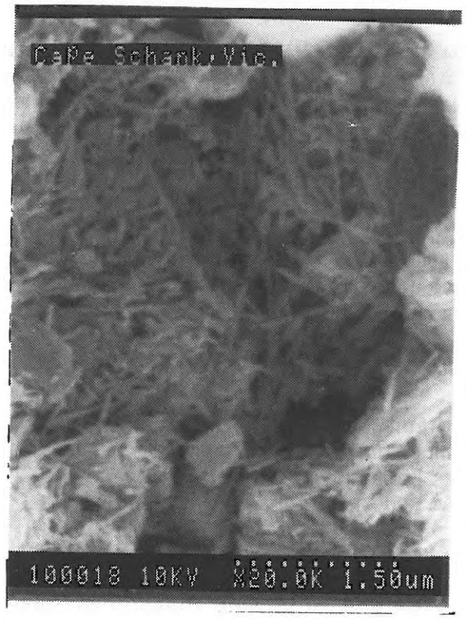
## Discussion and Conclusion

Although surface texture studies of quartz grains by SEM provide certain clues to the understanding of the related environment, the methodology is yet to be perfected (Rai, 1987). However, we can still draw some conclusions about the transportational and depositional environments from the surface textures of the revealed sand grains.

The controlling factors in the distribution of various surface textures of grains are both endoscopic and exoscopic (Bull, 1981), together with several stages of modification after deposition. Therefore, the combination of different surface textures found in the same grain suggests that these sediments have been subjected to various environments during the Quaternary.

On the surface of the quartz grains which have suffered repeated redeposition in environments of different physical and chemical characteristics, there are usually combinations of textures characteristic of each of the separate environments. Although Krinsley and Doornkamp (1973) considered the "combined glacial-subaqueous environment" as the most common one, some other authors regarded the combination of aqueous environment with an earlier aeolian environment as the most common one or vise versa (Nordstrom and Margolis, 1972; Krinsley *et al*, 1976; Fillon *et al*, 1978).





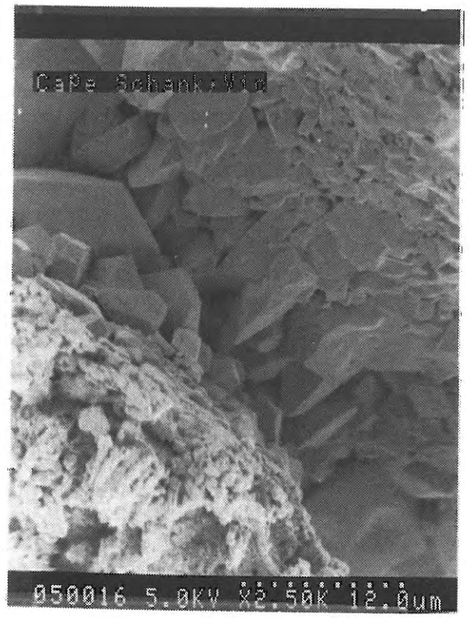




PLATE 8: Top left: Upturned plate; beach sand, Fingal Beach, Cape Schanck. The oriented up-turned plates have been subjected to solution and precipitation. This upturned plate can only be observed under high magnification.

PLATE 9: Calcrete surface textures and carbonate cements; calcrete (top right), palaeosol (bottom left), abd aeolianite (bottom right) from Fingal Beach, Cape Schanck. Top right: Calcrete surface textures are characterised by some fabric biogenetic carbonate structures. Bottom left: Surface adhering of aragonite and grain-to-grain needle-like aragonite cements. Bottom right: High magnesium calcite crystal pattern and its cement between grains.



The evidence gained in our study shows that quartz grains with combinations of surface textures characteristic of aeolian, subaqueous and diagenetic environments are extremely frequent in the sediments. The sand grains from the study area have been subjected to several processes.Aeolian processes were extremely frequent on this coast. The aeolianites studied reflect the influence of aeolian transport, marine modification, foredune building and calcium carbonate cementation.

The high degree of rounding of the sand grains, or at least the rounding along the edges, can only be derived primarily from the original aeolian environment with the additional effect of mechanical abrasion in a later subaqueous environment. If the sand grains were not modified by wind, but merely by subaqueous action, the sand grains would not be as spherical as those we observed. Our sand size analysis data suggests that the sand grains mostly travelled as saltating or creeping bedload and that they probably experienced a succession of high velocity collisions. As tested by Bagnold (1941), the kinetic energy of each sand grain was at least partly converted into elastic energy in the grain at the time of collision. When comparing the typical velocity of wind drift sand with that from a subaqueous environment, the elastic energy of the former may be several hundred times greater than that of the latter (Bagnold, 1941). Therefore, the rounded sand grains are likely to refer to the products of an aeolian environment.

The ensuing stages of subaqueous environmental modification which create the textures superimposed on the primary aeolian textures justify the conclusion that the subaqueous environment was a moderately to highly turbulent. Under a marine environment, chemical actions and mechanical processes are dominant. Dissolution and precipitation in depressions, mechanical abrasion on edges and "V's" on flat surfaces ensue from these processes, resulting in polished grains with completely smooth surface.

After deposition, the sand grains were subjected to other processes of diagenetic modification. Quartz grains from diagenetic environments differ in their morphometric characteristics but possess similar surface textures to determined by the chemical aggressiveness of the environment of burial (diagenesis). When the grains are carried into the environment, the surface textures produced by the previous environments are modified under the action of the chemically active pore solutions. The result is a complex superimposed texture of diagenetic alteration. These are mostly textures of silica dissolution and precipitation, of secondary dissolution and precipitation, of deep surface etching of the grains, of capping layer formation, of quartz crystal growth, and of the formation of oriented chemically etched V-forms and triangular depressions (Krinsley and Doornkamp, 1973; Tankard and Krinsley, 1975).

In the quartz grains examined from this environment, the primary surface textures of the original environment or of the transportational and sedimentary environment are completely obliterated by diagenetic textures in some cases, while in others textures of the subaqueous or aeolian (or aeolian-subaqueous) environment, although modified, are distinguishable, under the diagenetic textures. Such grains are characteristic of some varieties of the Neogene and Quaternary rocks subjected to abrasion along the coast, and there are similar grains which show diagenetic textures superimposed by later textures of subaqueous abrasion.

However, the aeolian features on the sand grains are not as clear as those from the typical hot desert. The rounding of the sand grains, the upturned plate and the aeolian precipitation development are not as distinct as those from hot deserts. Instead, most sand grains have the features of a littoral environment.

The calcium carbonate cementation of previously deposited sand could be the last stage. The aragonite cementation and high-Mg calcite cementation suggests a marine depositional environment rather than a fresh water environment.

To sum up, the surface microtexture study by scanning electron microscopy reveals that sand grains from the Fingal Beach coastal cliffs of Cape Schanck have undergone several stages of sedimentary processes: aeolian transportation, subaqueous modification, dune building , followed

by a final stage of diagenetic cementation. Evidence of glacial source material is rare, which suggests that the sand grains have not been subjected to the latest glacial action and that they are not fresh but have undergone several repeated processes.

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QUATERNARY AUSTRALASIA PAPERS
Paper: Quaternary Australasia 10/1 (1992)

# PALAEOECOLOGY AND ARCHAEOLOGY IN THE EAST KIMBERLEY

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## Abstract

Since 1987 we have been trying to integrate current knowledge of Aboriginal land use and resource exploitation (Head & Fullager, 1991) with the long-term prehistoric record. We present here preliminary results from the prehistoric part of the project; radiocarbon dates for palaeoecological sites and a description of initial archaeological investigations.

## The Study area

The area lies on the coastal plains in the far north of the East Kimberley, betweeen the Ord and Victoria Rivers (Figure 1). It includes Murinpatha, Jaminjung, Gadjerong and Miriwoong country, with many people having been born and worked on cattle stations right across this country as well as further south. Aboriginal people have mixed feelings and memories of the cattle stations, some nostalgic, others filled with horror (Shaw, 1981; McGrath, 1987; Rose, 1992). Whatever their feelings, Aboriginal people now resident in Kununurra maintain strong links with these lands.

We have focused on an area northeast of Kununurra where the local Aboriginal community has established an outstation, Marralam, on an area of land excised from Legune Stattion, just inside the Northern Territory border. Comparative work has also been done on nearby Spirit Hills and Carlton Hill Stations. The environment comprises rocky sandstone uplands, alluvial flats and saline tidal flats. Several billabongs, including the one at Marralam, hold permanent fresh water. The vegetation is predominantly savanna grassland and open woodland, with some areas of more mesic vegetation around springs and watercourses.

## Palaeoecology

A number of sites have been investigated for pollen and charcoal analysis since the 1987 field season. The seasonal tropics of northern Australia have always been problematic in this regard since few lake or swamp sites hold water throughout the dry season, leading to the oxidation and/or deflation of sediments when the water body dries out. Heavy wet season rains can also lead to flood scour and disruption of the sedimentary record.

With the local knowledge of Biddy Simon and other members of the Marralam community, and Daisy Djanduin of Kununurra, we were able to identify and core a number of swamps from which we report three with radiocarbon dates. These were ones that were either least likely to dry out, or close to significant occupation sites and which might thus show cultural influences (Figure 1).

## Coornamu Swamp

The swamp lies in an enclosed depression in the sandstone country adjacent to the west bank of Sandy Creek. It appears to have no fluvial input, but its overflow would feed into Sandy Creek during the wet season, The site is in the centre of favoured hunting country for the Marralam Community. A D-section core produced 35cm of uniform lake mud. Augering below this depth showed very inorganic clay. A sample from 33-35cm gave an AMS date of 2,110 ± 65 BP (Beta-25054, ETH-3896).

## Green Swamp

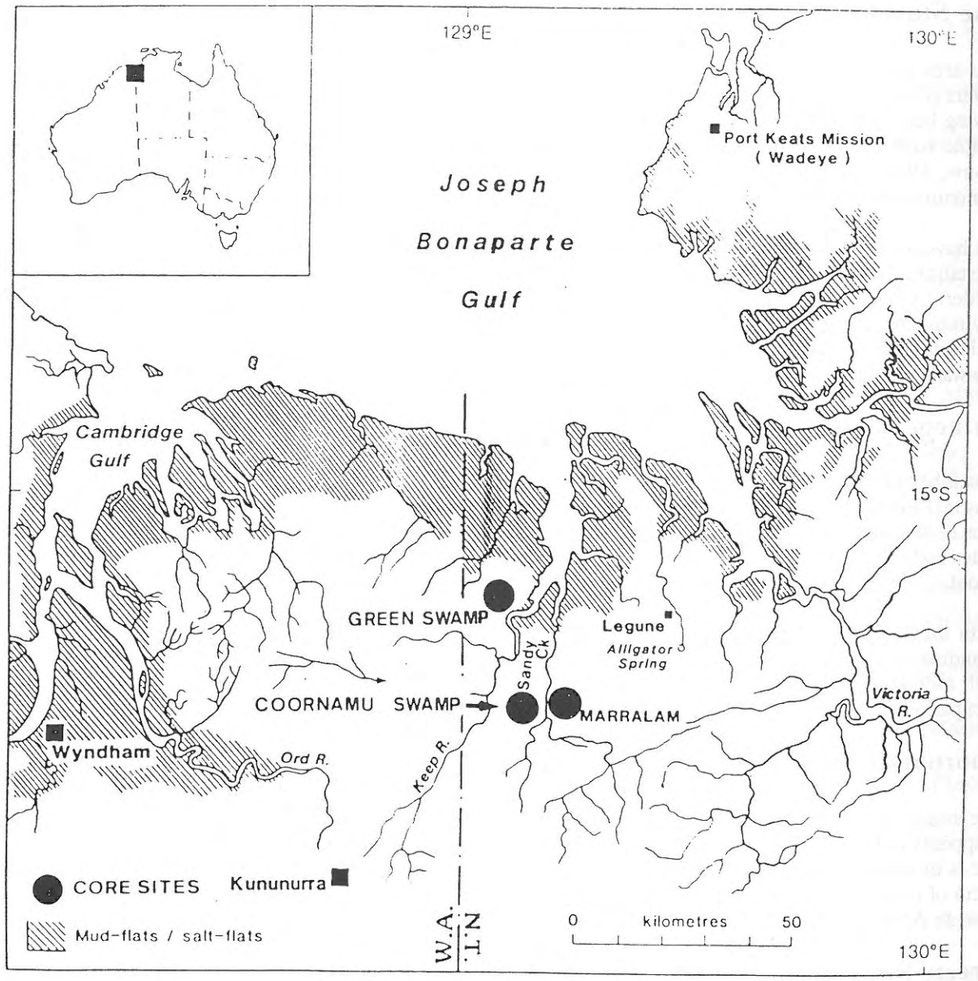
Green Swamp is an enclosed depression in sandstone country on the west bank of the Keep River. It may have originated as a cut-off meander of the river, but is now quite separate from the main channel. Here 36cm of lake mud was found to overlie yellowish clay. A sediment sample from 34-36cm gave an AMS date of

1,025 ± 75 BP (Beta-25055, ETH-3897). All the samples described here were chemically pre-treated to eliminate carbonates.

## Marralam Billabong

This site was of great interest because of the settlements that have occurred around it. The original Legune homestead was located there, and it has clearly been of significance to the Aboriginal people for a long time. It is less than ideal as a pollen site as it becomes part of a drainage line during the wet season. However, it has the advantage of holding water all year, which is one reason for human occupation. Only 20cm of lake mud could be extracted from the billabong. The sediments contained many small charcoal inclusions. A charcoal-mud sample from 15-18cm gave an AMS date of 310 ± 70 BP (Beta-28327, ETH-4732).

**Figure 1: Location map of the study area in East Kimberley.**






## Sediments, dating and changing environments

The lake muds from which the three date samples came are all highly inorganic (loss on ignition <10%). Pollen is preserved throughout at least the Coornamu and Green Swamp cores, but is highly eroded. This suggests that water levels in the basins may have fluctuated regularly (presumably mainly on a seasonal basis), but that the basins did not dry out for long enough periods to oxidise pollen completely. Such conditions have prevailed at Coornamu from about 2,100 BP, and at Green Swamp from about 1,000 BP. While this may represent simply the most recent phases of swamp accumulation, older sediments having been scoured away, these are both enclosed depressions and less likely to be scoured by the higher velocity flood waters found in the main drainage lines.

On the basis of thermoluminescence dates from dunes at the Berkeley River mouth, on the western side of Joseph Bonaparte Gulf, Lees *et al.* (in press) argue for three periods of dune instability in the last 3,000 years, at approximately 3,000 BP, 1,600 BP and within the last 1,000 years. They suggest increasing climatic variability over this period as the main cuase, with the dune intitiation episodes probably due to short periods of increased aridity.

At first glance, there are apparent contradictions between an arguement for increased climatic variability involving short arid periods, and the depositional evidence presented here that suggests less fluctuation in water levels in the last 1 - 2,000 years than previously. There are several possible explanations which need to be considered.

i) The climatically-variable period includes not only increased aridity but periods of increased precipitation that maintain water levels and thus sedimentation.

ii) Different processes are operating in coastal and fluvial systems even though the latter are not far inland.

iii) The dune movements are extremely short-term events, not discernable in the swamp depositional record. This may be essentially a sampling problem, an artefact of the very different contexts in which the two dating techniques operate.

There are parallels between this situation and that of southeast Cape York. There Stephens & Head (1990, in prep.) found considerable variability in the timing of the onset of organic deposition at a range of sites. Some could be attributed to local factors, but there was an apparently synchronous phase of deposition at several sites since about 2,500 BP. This was interpreted as indicating more available and reliable surface water in the last 2,500 years than previously. Again, there is some discrepancy between this and the TL date of 2,000 ± 1,000 years for dune instability at Cape Flattery (Lees *et al.* 1990). There is considerable potential for closely integrated studies involving dating (by both TL and C14) of erosional and depositional contexts in northern Australia.

## Archaeology

Previous archaeological research in the region provides a broad chronological framework and an outline of the stone tool sequences with considerable discussion on exchange, diffusion and the origin of stone point industries (e.g. Flood, 1970; Dortch, 1972, 1977; Jones, 1985; Bradshaw, 1986). Koolan Shelter 2 in the West Kimberley has evidence of marine exploitation as early as 27,300 years ago (O'Connor, 1989).

We visited a variety of rockshelters and old camping places, all of which have been frequented by Aboriginal people before, during, and after "station times". Consequently, many of the rockshelter sites have paintings, caches of ochre, and archaeological deposits.

Following the expressed interest of the Aboriginal community in the historical period we surveyed an area around the Marralam billabong for archaeological sites and selected an area close to an old boab tree for test excavation. This area around the boab seems to be raised and protected from myriads of stream channels which flood the area in the wet. It also seemed likely that the boab would be a centre of activity during various times of the year, providing shelter and a focus for social activities. A pit 50cm x 50cm was excavated to a depth of 46cm. The number of stone artefacts decreases with depth. No stratigraphy was visible and a metal cufflink was found at the lowest level. There is insufficient charcoal for conventional radiocarbon dating, but

the lowest level has, mixed in it, elements of the early European periods and no clearly prehistoric levels were excavated.

All material was sieved through a fly wire mesh (1mm x 1mm). Materials recovered in all levels include charcoal, wood, bone (mostly tortoise carapace), metal, ochre and stone. Seeds, glass and egg shell were present in the upper levels.

Excavated materials have not been analysed in detail but we make the following general remarks on the stone assemblage. Three distinct activities have been indentified so far: i) the production of bifacial points, ii) the use and resharpening of flake tools; and iii) the discard of broken points. Fine-grained chert artefacts are mostly small (less than 10mm maximum length) and they include pressure flakes. Quartz, including milky and clear crystal quartz, is common and includes debris from point manufacture and bipolar core reduction. Retouched and other quartzite flakes are common. The sources of quartzite for use as tools include outcrops exposed near the margin of Marralam billabong. The range and density of artefacts suggests intensive use of the area around the billabong and access to good quality local stone sources in the surrounding hills.

## Future work

Future work is being directed towards rockshelter sites which will provide a prehistoric archaeological record with preservation of organic residues on stone tools (Fullagar *et al.* 1992) and sedimentary contexts in which pollen may be preserved.

## Acknowledgements

The project would not have been possible without the involvement of many people of the East Kimberley, particularlly Biddy Simon, Polly Wandanga and Light Balgarri of Marralam. We especially thank Nancy Williams, Ian Kirkby, Daisy Djanduin, Ben Ward (chairman of the Waringarri Corporation) and Kim Akerman. We are grateful to Brian Lees for discussion of potential pollen sites and access to unpublished data. Funds were provided by the Australian Institute of Aboriginal Studies and the University of Wollongong. Val attenbrow commented on a draft

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QUATERNARY AUSTRALASIA PAPERS
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# MORE ON JOHN PICKARD'S DIET OF DIPROTODONS

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As AQUA members who read their *Quaternary Australasia* will be aware, Pickard (1990) reported that he had found a tantalizing reference to the stomach contents of *Diprotodon* and requested further information from readers. He wrote up the information he received in the last issue of *Q.A.* (Pickard, 1991), including a quote from Neville Pledge that there is "about a cupful" of the material left in the South Australian Museum. I have subsequently discovered what happened to some of it.

It seems that part of the material was used to radiocarbon date the Diprotodons. This was first reported by Daily (1960, p. 12) and as this is a fairly obscure reference, I follow Pickard's example and quote it at length.

> "At the request of the late Sir Douglas Mawson, carbon 14 datings on *Diprotodon* remains from Lake Callabonna and Orroroo were carried out in New Zealand. An age older than 40,000 years B.P. was given for a sample of food remains of *Diprotodon*, collected by Mr. A.H.C. Zeitz at Lake Callabonna in 1893. Molars of a *Diprotodon* collected on the same lake by the University of California - South Australian Museum 1953 field party, were dated 6,700 plus or minus 250 years B.P. ... The Callabonna datings at first sight may appear anomalous, but as they are referable to two specimens collected as different localities from the lake sediments and as there is no stratigraphic information on the Callabonna deposits, their ages are probably real."

The involvment of Sir Douglas Mawson in the submission of the material to the radiocarbon dating laboratory probably explains the fact that Grant-Taylor & Rafter (1963, p. 143) incorrectly named Mawson as the collector of both the "presumed crop contents of Diprotodon" [sic!] (NZ-205: >40,000 B.P.) and the lower molars from which dentine was used for the other date (NZ-206: 6,700 ± 250 B.P.). Assuming that Daily's account above is accurate, it appears that Grant-Taylor & Rafter's statement that "it had been believed that the "crop contents" NZ-205 were related to the animal whose teeth were dated NZ-206" is also mistaken.

The discrepancy between the two original radiocarbon dates is probably the result of the unreliability of dentine as dating material. Tedford (1967, p. 149) argued that the older date was more likely to be correct on the basis that sand ridges of last glacial age overlie the sediments containing *Diprotodon* etc. at Lake Callabonna. A specimen of wood from the base of these sediments submitted for radiocarbon dating by Tedford in 1971, was determined at >39,900 BP (I-5479), confirming NZ-205 based on the stomach contents and contradicting NZ-206 from dentine (Tedford in Buckley, 1973).

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QUATERNARY AUSTRALASIA PAPERS
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# SALVAGE OF A DIPROTODON FROM NORTH-WESTERN AUSTRALIA

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In October 1991 an officer of the W.A. Agricultural Protection Board found large fossil mammal bones in a creek bed in the north-west of W.A., while checking a noxious weed infestation site that he had last visited some two years ago. The bones were embedded in sediments now forming a level floor to the creek. He reported his find to Peter Kendrick of the Karratha office of the W.A. Department of Conservation and Land Management, who accompanied him back to the site early in November. Peter Kendrick identified the bones as probably those of *Diprotodon*, collected some surface specimens of small bones and mollusc shells, and reported the find to the W.A. Museum.

This report posed something of a dilemma: the curator responsible for vertibrate palaeontology was away on field work in Antarctica, and the W.A. Museum had a zero budget for field work in the current financial year. On the other hand, the cyclone season was just begining in north-western Australia, and the gravel overlay which had presumably been removed from the site by the last cyclone could easily be redeposited by the next one. The speciment might also be lost to the museum because its whereabouts became fairly widely known locally. A volunteer party consisting of the authors was therefore assembled and launched on invisible finance. Guthrie, who happened to be on sabbatical in Perth at the time, added expertise in plaster jacketing and experience in recovering remains of large mammals, and Kendrick expertise in fossil molluscs and Quaternary stratigraphy to Baynes' experience of collecting fossil mammals (almost entirely small species!). Time and other commitments permitted us to devote just eight days between 26 November and 3 December to the enterprise. It was not a propitious choice of dates from the weather point of view -- 42.5° was the lowest maximum we experienced during the five days on site, and 46.7° the highest, and none of us were acclimatised to the heat. Without generous local support in the form of sunshades and a generator and rock hammer provided by the Karratha office of Cockburn Engineering, and a small army of acclimatised local volunteers organised and ably led by Peter Kendrick, we would not have succeeded.

The *Diprotodon* bones were exposed at the surface of a hard calcareous alluvium containing fossil crab claws and shells of mullusc species (*Telescopium telescopium* and *Terebralia palustris*), characteristic of mangrove habitats, plus calcareous nodules and water-worn pebbles derived from the Pilbara block. These clasts coarsened upwards towards the surface of the sediments. The top of the bed was estimated to lie some 2 - 3 m above present sea level, indicating that the sediments dated from the high sea-level stand of a Pleistocene interglacial. The degree of weathering of the mollusc shells suggested that the deposit could pre-date the last integlacial. This point will receive further study.

The bones were spread along about 180m of the creek bed, with the long axis of the distribution approximately aligned with the direction of the present channel. The first item at the up-stream end was a fragment of one of the proximal long bones, probably from the head of a femur which had otherwise eroded away. This was followed by the left shoulder blade and then a more concentrated scatter of ribs, distal long bones, teeth and a partial skull consisting of the premaxillae with upper incisors, some of the palate with a few molars and part of the basicranium. Close to the downstream end of the scatter was the largest group of bones consisting of the pelvis, several vertebrae and ribs, most of the left front limb and both lower jaws. Although the bones lay predominantly at the top of the bed, some penetrated to a depth of over 0.5m and were positioned more or less vertically.

Most of the bones visible at the surface were excavated during the field work. Many had cracked or fractured during settlement of the matrix and were recovered in fragments. There was only time to plaster jacket the largest items. Although the speed of the salvage excavation necessarily increased damage to the specimen, the approach appeared justified when cyclone Ian swept across the area on 3 March 1992, dumping 100mm of rain and causing local flooding.

The W.A. Museum has now obtained sponsorship from the Robe River Mining Co. to fund preparation and further investigation of the specimen. Susan Jennings, who has been working with Peter Murray in Alice Springs, will be moving to Perth in early April to carry out the preparation.

Until preparation and identification of the elements have been completed we are able only to provide preliminary interpretations of the taphonomy. We consider that the bones represent one mature individual of *Diprotodon*. Under one hypothesis the animal died in or beside a riverbed a short distance upstream of the site some months at least before its remains were incorporated into the sediments. The carcase, which lay on probably its left side, was scavenged and many of the skeletal elements were scattered. However, the pelvis, some vertebrae with attached ribs, the left forelimb and the lower jaws remained attached to the hide on the underside of the carcase. Very substantial rainfall, probably from a tropical cyclone, occurred in the river catchment. River flow increased to flood levels and transported coarse channel sediments and the *Diprotodon* bones downstream until they reached the river delta. Here they settled into depressions at and a little above the intertidal zone, either because they were trapped by the mangrove roots or, more likely, because water speed diminished. The large group of bones attached to the hide was carried the greatest seaward distance because the hide acted like a sail and dragged the heavy bones along. Under an alternative hypothesis, the *Diprotodon* made its own way into the sea or mangrove, became mired at the site where the pelvis was found, drowned and the detached bones were later redistributed landward by a storm surge, probably caused by a tropical cyclone.

The specimen is important both because it is the first articulated *Diprotodon* from Western Australia, and, being in marine sediments, can potentially be dated relatively accurately.



QUATERNARY AUSTRALASIA PAPERS
**Paper Abstract: Quaternary Australasia 10/1 (1992)**

# THE LATE QUATERNARY VEGETATION AND CLIMATIC HISTORY OF THE BLUE MOUNTAINS, N.S.W., AUSTRALIA

Jane Chalson
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Sydney University, Sydney 2006

Abstract of Chalson, J. 1991. *The Late Quaternary vegetation and climatic history of the Blue Mountains, N.S.W., Australia.* Unpublished Ph.D. Thesis, University of New South Wales.

A review of the literature relevant to the Late Quaternary environmental history of the highland region of New South Wales has been undertaken. Studies of Quaternary vegetation history in Australia have been hampered by the difficulty in identifying the pollen of the major family which dominates the south-eastern portion of the continent, the Myrtaceae. Few long palynological records have been published from sites in N.S.W. and thus data over 25,000 years old is sparse. Studies concerning climatic change in the Holocene period are hampered by the small amplitude of possible changes, and considerable controversy is revealed in the literature.

Pollen analysis of sediment cores from a series of swamps in an altitudinal sequence across the Blue Mountains was undertaken. The altitude change across the study region is associated with a strong climatic gradient and thus these sites were sensitive to small-scale, climatically-induced changes in the vegetation which were recorded in the pollen spectra. The study region is dominated by species of the family Myrtaceae and in order to analyse vegetation change, it was necessary to develop a method to identify dispersed pollen of this family to species level.

The reference collection enabled identification of 79% of the dispersed Myrtaceae types of pollen. A vegetation, charcoal and environmental history of the local area immediately surrounding each of the eight swamps in the study has been reconstructed. The information from all of these sites has been combined to produce a climatic history of the study region. One site has a basal date of 34,000 B.P. and, thus a new long palynological record is included in this study.

From this long palynological record it was concluded that temperatures reached a minimum of approximately 7.6°C below modern values in the coldest month and approximately 9.4°C below modern in the hottest month between 34,000 B.P. and 32,000 B.P..

A series of small fluctuations in effective precipitation between 11,000 B.P. and the present have been demonstrated and a model for these oscillations proposed. Some analysis of the relationship between climate and vegetation change and the charcoal record has been undertaken. A discussion concerning the relationship between climate change and vegetation change is included.

# Tassie's ancient secrets revealed

● Professor Colhoun with a rock sample

By DICK CRAWFORD

ANCIENT rock samples from an HEC power development are helping fill in the jigsaw of Tasmania's former climates.

The rocks, from bore holes in a valley near the Lemonthyme Power Station on the North-West Coast, contain 40,000,000-year-old glacial deposits laid down when Tasmania rubbed shoulders with the Antarctic continent.

The significance of the rocks, unearthed in the mid-1960s, was guessed in 1975 by the professor of geography at the University of Newcastle, Professor Eric Colhoun, then at the University of Tasmania.

But it has taken until this year for his theory to be proved.

Examination of the rocks had revealed two glacial deposits and a layer of organic material of indeterminate age.

Initially it was thought both glacial deposits pre-dated the organic material.

However Professor Colhoun, backed by an Australian Research Council grant, had been able to demonstrate the organic layer occurred between the two glacial deposits.

A key to unlocking the story the rocks had to tell was the examination of pollen samples from the organic material by palynologist Dr Michael MacPhail.

Dr MacPhail was able to date the organic layer at about 35,000,000 years old.

Professor Colhoun said this indicated the oldest glacial deposit was older than 35,000,000, perhaps about 40,000,000 years old.

The deposit could only have formed when Tasmania was at about latitude 60 degrees south.

"That puts Tasmania right up against coastal Antarctica," he said.

"It means this very early glaciation of Tasmania took place when it was just breaking away from the northern part of Antarctica.

"Tasmania is drifting north, north-east at roughly two to three centimetres a year and this drift has been taking place for the past 50,000,000 to 60,000,000 years."

Professor Colhoun said the rock samples were unique. There was no other glacial evidence from the same period in mid-latitudes of the southern hemisphere.

Other rocks of similar age were still peripheral to the Antarctic continent.

Professor Colhoun said pollen and fossil leaves from the organic deposit would also provide valuable information about the flora of lowland valleys of Tasmania immediately after the glaciation.

The leaf impressions were being studied by Dr Bob Hill, of the University of Tasmania's botany department.

The pollen already indicated evidence of plants similar to species existing today in New Guinea and New Caledonia.

The implications were that either the forest that produced it was of a type occuring in climates warmer or more humid than present day Tasmania's, or the species of plant surviving in New Guinea and New Caldonia could adapt to colder conditions.

Professor Colhoun said it was his guess the organic material was from a very wet temperate forest.



# AUSTRALASIAN QUATERNARY ASSOCIATION (AQUA)

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## APPLICATION FOR MEMBERSHIP

The **Australasian Quaternary Association** is an informal grouping of people interested in the manifold phenomena of the Quaternary. It seeks to encourage research (by younger workers particularly) to promote scientific communication in its region, and to inform members of current research and publications. It holds biennial meetings, the next being an inter-INQUA international conference in Canberra in May 1993. The Association publishes the newsletter ***Quaternary Australasia*** twice a year. The annual subscription is **A$20** or **$10** for students and unemployed or retired persons. Return this membership application to the **Treasurer**, Mr Albert Goede, AQUA, BOX 338 Sandy Bay, Tasmania 7005

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## COVER ILLUSTRATION

The front cover illustration is a tribute to the late Dr. Gurdip Singh. The three over-lapping pollen diagrams represent part of the range of Gurdip's research interests. The uppermost part of cover illustration is from the pollen diagram resulting from his analysis of the long sediment cores recovered from Lake George in the Southern Tablelands of New South Wales. Here Gurdip demonstrated, in one of the few long Australian pollen Quaternary sequences, the alternating conditions of successive vegetation changes reflecting the climatic shifts during successive glacial/integlacial/interstadial periods, and the late Quaternary impact of human activity within the landscape. The central part of the illustration is one of his earlier pollen diagrams from his palynological research in Northern Ireland. This particular diagram, derived from the pollen analyses of sediments recovered from an infilled lake basin at Ballydugan, County Down, illustrates the conditions of vegetation change which have subsequently become seen to be typical of the environmental change associated with the amelioration of climate at the end of the last glacial period thtoughout this temperate region of coastal northwest Europe. The lowermost part of the cover illustration shows part of a pollen diagram derived from the analysis of sediments recovered from an infilled lake basin in the Thar Desert, northwestern India, a northern hemisphere continental arid region which lies at a similar latitude to the arid region of Central Australia. In this study, Gurdip was able to demonstrate the effects of a series of climatic changes from the Late Pleistocene though into the Holocene, changes which, he argues, have very close parallels in the Australian arid zone Quaternary history. The illustrations are derived from, top to bottom: Figure 3 in Singh, G., Kershaw, A.P. & Clark, R. 1981. Quaternary vegetation and fire history in Australia. pp 23-54 in Gill, A.M., Groves, R.A. & Noble, I.R. (eds) 1981. *Fire and Australian biota*. Australian Academy of Science, Canberra; Plate XI in Singh, G. 1970. Late-Glacial vegetational history of Lecale, Co. Down. *Proceedings of the Royal Irish Academy*, 69, Section B, No. 10, 189-216; Figure 2 in Singh, G., Wasson, R.J. & Agrawal, D.P. 1990. Vegetational and seasonal climatic changes since the last full glacial in the That Desert, noerthwestern India. *Review of Palaeobotany & Palynology*, 64, 351-358.