Australian Quaternary Newsletter

No.8 November 1976

This issue consists mainly of the Quaternary Shorelines report, and reviews of various conferences and seminars that have taken place in 1976. Very few research reports have reached us over the last year, although the interest in and importance of Quaternary studies in Australia continues to increase. Any contributions, even just a few lines, on present research projects would be welcome for the next issue, planned for April 1977.

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ANOTHER UNDERGRADUATE QUATERNARY COURSE

This year the Department of Geography at the Australian National University offered for the first time a unit of Physical Geography which has as its theme the climatic change over the last 50,000 years. Unlike the Monash Geography Quaternary Studies unit, which is at third and fourth year level, the ANU unit is for first year students and aims to introduce various aspects of climatology, geomorphology and biogeography, by showing how specific techniques can be used to interpret evidence from the past. Although this required a rather selective approach, the students clearly found the guiding theme of applying process studies to specific problems more interesting than the traditional study of principles and processes in isolation. In addition to Geography majors, students from Prehistory, Geology, Botany and Asian Studies were enrolled in 1976. Topics covered included general climatic processes, historical climatic records, palaeoenvironmental implications of fluvial and desert landforms, dating methods, oceanography and deep sea core records, plant ecology and treelines, tree rings, pollen analysis and faunal change. The year concluded with a summary of the climates of south-east Australia; the students demonstrated a realistic scepticism having been shown the shaky chain of interpretation on which the conclusions rest. Staff and students agreed that it was a more challenging course than most other introductory units. The course will be offered again in 1977.

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VISIT TO AUSTRALIA OF CHINESE QUATERNARY RESEARCH GROUP

From 20 November to 11 December 1976, a group of Chinese Quaternary scientists will be visiting Australia. This is a reciprocal tour following the visit to China last November by a group of Australian Quaternary workers from the Australian National University. The group will spend a few days in Canberra, making a short trip to Lake George from there, and will then travel to Lake Mungo, in western New South Wales, and to Arkaroola and the Lake Frome basin in South Australia before reaching Adelaide. From there, they will travel to Melbourne by way of Mt Gambier and Western Victoria, and will spend the last few days in Canberra and Sydney.

The members of the Chinese group and their affiliations are:

WEN Chi-Chung (Head of the group). Responsible member for Quaternary Geology Laboratory, Kweiyang Institute of Geochemistry, Academia Sinica. Specialty: Quaternary Geology

AUSTRALIAN ACADEMY OF SCIENCE

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REF.: IA 11

MEMORANDUM TO AUSTRALIAN REPRESENTATIVES ON INQUA COMMISSIONS, ETC.

The scientific disciplines that are brought together under the auspices of INQUA are so many and so diverse that the National Committee of the Australian Academy of Science has directed particular attention firstly to ensuring that Australian representation on Commissions, Sub-Commissions and Working Groups is adequate, and secondly to affording ways of drawing together persons working in different disciplines.

The *Australian Quaternary Newsletter*, issued through the good offices of the School of Pacific Studies of the Australian National University, and supported in part by personal subscriptions, would welcome short reports from time to time from Australian members of INQUA specialist groups. It is hoped that you may be able to send in some account of the activities of the group with which you are concerned, at such time as it may seem appropriate to make a review.

Contributions to the Newsletter should be sent to one of the editors:-

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The next issue of the Newsletter is planned for April 1977.

You will be aware that the X INQUA Congress is to be held in Birmingham in August 1977. Should there be any matter which you feel the Australian delegation might raise in relation to policy, please write to the Chairman of the National Committee for INQUA, c/- Australian Academy of Science, PO Box 783, Canberra City, ACT, 2601. Any item put forward for consideration by the General Assembly should be submitted to the Executive six months before the Congress, and would normally be referred to the National Committee in advance, probably in March/April 1977.

Edwin S. Hills
Chairman
National Committee for INQUA

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26 January 1977

FENG Yin-Fu (Deputy head of group). Deputy division chief, Foreign Affairs Bureau, Academia Sinica

CHU Ping-Chuan. Scientific worker, Kweiyang Institute of Geochemistry, Academia Sinica. Specialty: Isotope Geology

WANG Sung-Shan. Scientific worker, Institute of Geology, Peking, Academia Sinica. Specialty: Isotope Geology

KUNG Shao-Chen. Scientific worker, Peking Institute of Botany, Academia Sinica. Specialty: Palynology

LIU Hsien-Wen. Scientific Worker, Lanchou Institute of Glaciology, Cryopedology and Desert Research. Academia Sinica

SHAO Ming-Hsin. Interpreter, Foreign Affairs Bureau, Academia Sinica

Laboratory visits and lectures have been arranged in the major cities. If you would like to meet the Chinese visitors, specific details of their programs in each city can be obtained from D. Walker, Australian National University, Canberra; C. von der Borch, Flinders University, Adelaide; and B. Joyce, Melbourne University.

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NATIONAL COMMITTEE FOR QUATERNARY RESEARCH

AUSTRALIAN ACADEMY OF SCIENCE

Annual Report for 1975

The Statutes and By-Laws of the International Union for Quaternary Research (INQUA) were modified at the IXth Congress which was held at Christchurch, New Zealand, in December 1975, so as to conform with the requirements of the International Council of Scientific Unions (ICSU) for recognition by that body. Affiliation with ICSU will facilitate liaison with other Unions and participation in joint programs, for example the International Geological Correlation Program, and also with UNESCO. Affiliation with ICSU was approved by the General Committee of ICSU at its meeting in Ankara on 20-21 September 1974. After the Congress, the Council of the Academy agreed to a recommendation of the chairman of the National Committee, that Australia should seek to increase the level of its adherence to INQUA to Category II, in view of the notable growth of research in Australia on topics relating to the Quaternary period. A meeting of the National

Committee planned for 1974 was postponed to April 1975, owing to delays in the receipt of documents relating to the above matters, from overseas. At this meeting the committee approved the changes on the Constitution of INQUA and noted that the Xth Congress is planned for August 1977, in Birmingham, U.K. The acceptance of Australia's application for Category II membership was noted with approval. The success of an exhibition of Quaternary research materials, which had been displayed at the National Library for nine months and had been featured at the Christchurch Congress, was noted. The material is available for circulation to Australian museums.

The *Australian Quaternary Newsletter*, which was established and circulated with Academy support in 1973, has been well received and printing and mailing costs are now covered by subscriptions received, editing and typing being undertaken by the departments concerned in the ANU Research School of Pacific Studies. The *Newsletter* is available for the dissemination of general interest to Quaternary research workers throughout Australia.

The Committee has recommended that a National Symposium be held under Academy auspices in 1977, on Physiology and Quaternary Environments, a topic proposed by Professor D. Walker (ANU). This has been agreed to by Council, with limited financial support, and planning is proceeding. The Committee is also examining other ways of assisting communication between workers in Australia, especially in inter-disciplinary and multi-disciplinary fields, which should also improve collaboration both internally and internationally. The invitation of Academia Sinica for a group of quaternary research scientists from the ANU to visit China for three weeks from mid-November is especially noteworthy.

Membership of the Committee changed during the year with the resignation of Mr G. Blackburn and Professor D.J. Mulvaney, and the acceptance of membership by Dr G.G. Beckman and Dr R.M. Jones.

The Committee determined not to seek membership of the Executive Committee of INQUA, but to support at this time a nominee from New Zealand. Professor Jane M. Soons, University of Canterbury, Christchurch, was elected Vice-President.

The undermentioned persons are Australian members of Commissions, Sub-Commissions and Working Groups of INQUA.

E.D. Gill, member of the Commission on Quaternary Shorelines, President of the Sub-Commission on the Pacific and Indian Oceans. Mr Gill has also been a correspondent for the Commission on the Palaeogeographic Atlas of the Quaternary.

H. Polach, is President of the Working Group on the Dating of Palaesols.

E.B. Joyce, is a corresponding Member of the Commission on Tephrochronology.

G. Blackburn, is a corresponding Member of the Commission on Palaeopedology.

An Australian Working Group is currently being formed on the Neogene-Quaternary boundary, in consultation with the National Committee for Geological Sciences.

It is anticipated, following correspondence with New Zealand members, that a Sub-Commission on the Quaternary Stratigraphy of Australia will shortly be formed, in collaboration with the appropriate geological groups.

C.R. Twidale has been a correspondent for the Commission on Neotectonics, and the preparation of a Neotectonic Map of Australia is currently being organised in collaboration with the Specialist Group on Tectonics of the Geological Society of Australia.

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CONFERENCES AND MEETINGS - 1976

Sign of the Times? Quaternary Geology and The International Congress

In a continent where bedrock is so frequently obscured by a surficial cover of late Cenozoic sediment and weathering mantles, an understanding of such deposits has often been conspicuously lacking from national geological concerns. Encouraging changes to this situation are now becoming evident in different ways. Although a systematic study of Pleistocene geology is still looked on as lying outside the scope and structure of most undergraduate courses there are several notable exceptions, the latest being the introduction of a course in Surficial Geology covering aspects of geomorphology and Quaternary Geology in the University of New South Wales. It is probably no coincidence that the lecturer in charge, Dr Mike Knight, and the Head of the Department, Professor Frank Beavis, have both come to that University via the Department of Geology at Melbourne.

Another encouraging sign of the growing appreciation and relevance of systematic Quaternary studies may be drawn from the success of the section devoted to it at the recent International Geological Congress held in Sydney. Whilst the I.G.C. always provides a full section devoted to Quaternary Geology its relevance in the northern hemisphere where most congresses have previously been located has long been established. There the practical application of glacial drift stratigraphy is

acknowledged by hydrologists, engineers and economic geologists alike. However, in Australia, a long-held tradition in some quarters of the profession regards things Quaternary as merely obscuring the 'real' stuff, i.e. the hard rocks underneath. Therefore the task of convening this section for the Congress was a cause for some apprehension; how many and what quality of papers would be presented? Would they be of interest to the general geological audience assembled at Sydney? Fortunately the events allayed those fears.

The Quaternary program, Section 12, proved to be a full one. Of the papers offered, 37 were accepted after vetting by the Congress Committee. These covered a wide range of topics drawn from many different regions. One might mention Professor Förster's (West Germany) contribution on 'Effects of Late Cainozoic Climates on the Geology of Central Iran', Dr Bardin (Moscow) on 'Antartic Glaciation History; present state of the problem', or Russell Harmon (Michigan) and his colleagues on a detailed and closely dated account of 'Sea-level changes in Bermuda during the last 200,000 years'.

Amongst Australian contributions, a valuable and new account of the late Cainozoic in Western Australia was provided by Don Glassford and Leo Killigrew from the University of Western Australia, Department of Soil Science, whilst Eric van der Graff and his co-authors gave a well documented paper on 'Western Australian Relict Drainage Systems'. Bob Wasson, Phil Macumber and Roger Callen contributed on the Pleistocene evolutionary history of areas in western New South Wales, northern Victoria, and South Australia respectively. On matters coastal, Bruce Thom, Edmund Gill and Peter Flood kept things moving apace.

One of the most encouraging aspects of the sessions' contributions was the generally high quality of papers presented. This was acknowledged by the sustained level of interest at the sessions that had to compete with, amongst other things, plate tectonics, cryptoperthites, Miocene nannoplanktonic biogeography, and the geology of Mars to mention just a few. But perhaps even more significant was the good attendance that the Quaternary sessions attracted. Many papers drew full houses exceeding some 200 participants which in view of the alternative concurrent attractions was very encouraging and augurs well for the future.

If ever there was any cause to doubt the value of systematic Quaternary studies in this country to our understanding of hydrology, engineering and environmental geology or even to the weathering and discovery of ore deposits, the success of Section 12 at the I.G.C. should have helped dispel that doubt. One can only hope that more geology departments will follow the lead of Melbourne, Canberra, and now the University of New South Wales, in offering alternative courses in Surficial or Quaternary Geology to students who may find its application both intellectually stimulating and practically relevant.

J.M. Bowler

REFLECTIONS ON THE 47TH ANZAAS

HOBART, MAY 1976

ANZAAS is supposed generally to be an overgrown and senescent organisation with real questions as to its relevance and future. However Quaternary studies proved to be one of the most viable parts of the Hobart conference. It mostly sheltered beneath the wing of the Anthropology (Archaeology) Section 25, with the exception of some reviews in Botany. There was a rather poor attendance of prehistorians from 'overseas' (i.e. Australia) and the audience of 30-60 people covered a wide range of expertise but had a common ground of interest for Tasmania.

Now Tasmania is undergoing a major transformation to previously accepted thought in both Prehistory and Quaternary Geology, and simultaneously vegetation histories with accurate chronologies are becoming available from several areas of the island. So the combination of a small audience, dilution of mainland influence to a point where it could not co-opt the proceedings, and the juxtaposition of three streams of new Quaternary research made for a rewarding week.

Eric Colhoun's enthusiasm lies behind much of the renewed interest in Tasmanian glaciation now that he is reassessing till bodies in many parts of the state. With Gus van der Geer and Albert Goede, he has tied down the chronology of the last major advance and defined earlier advances. The post-glacial changes are now much better known following the work of Mick McPhail on the vegetation history of the Tasmanian mountains. Mick, who unfortunately couldn't be in Hobart, has shown that, following deglaciation about 13,000 years ago, vegetation remained sparse until after 10,000 BP, when the more humid communities of the present day migrated into the region and became established. This late migration also appears in the very long pollen record from Pulbeena (Colhoun and van der Geer) and Hunter Island (Sandra Bowdler and Geoff Hope) in the north-west. These diagrams show open vegetation reflecting possibly dry as well as cold conditions during the last glaciation; rainforest does not appear in the post glacial record until the last few thousand years. Within the context of these findings, the new faunal records of Sandra Bowdler and Peter Murray are of particular interest. Sandra has shown that man was at least intermittently present in Northwest Tasmania during the height of the last glaciation, while Peter has found fragmentary remains of human occupation in Beginners Luck Cave in the Florentine Valley, in perhumid western Tasmania, dated to 12,000 BP. Mick McPhail's work on nearby Mt Field helps explain this find, and that of an extinct large kangaroo in a slightly older level, by showing that an extensive open herbland or steppe was present then. The open conditions of the Late Pleistocene apparently encouraged travel, presumably on a seasonal basis. Neither kangaroo nor man would appear to be suited to the dense mountain ash forest that clothed the area in the Holocene (until the advent of the Tasmanian Forestry Commission and their remarkable holocaust methods of clearance).

The ANZAAS week saw the demolition of a number of guesses about the ice age conditions in Tasmania; for example that dense rainforest lurked everywhere below the periglacial limits or that man could not have persisted away from the contemporary coast. This Quaternary palaeoenvironmental framework proved useful to other contributions by prehistorians. So although the Section worked in almost complete isolation from the rest of the conference, as is now usual in ANZAAS, it was itself an excellent example of multidisciplinary cooperation. The message to me is to look forward to the smaller ANZAAS meetings such as Hobart or Port Moresby which will have a strong regional input, in contrast to the large, less flexible, meetings in the large cities. Certainly with fares and conference fees going through the roof, the decline in popularity of ANZAAS can be expected to continue.

G. S. Hope

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DISCUSSION MEETING : THE NORTHERN GREAT BARRIER REEF

ROYAL SOCIETY, LONDON, JANUARY 1976

The general findings of the 1973 Royal Society - Universities of Queensland Expedition to the northern Great Barrier Reef were reported at this meeting. David Stoddart eloquently summarised the purpose, organisation and general activities of the expedition, and in concluding the meeting brought together the main problems which remain unsolved. It was clear from his paper, as well as those by other contributors, that this relatively detailed study of the geomorphology, sedimentology and stratigraphy of surficial reef deposits could not report unequivocally on the course of Holocene sea-level change. The ambiguous nature of the evidence (e.g. emergent corals, cemented rubble platforms, beachrock, cay sands) was stressed with many explanations being offered. Elevations of these features show an array of heights. Difficulties in the interpretation of sub-surface core and geophysical records were also subject to discussion. Yet it was felt that the expedition had provided a new stimulus to geological-geomorphological reef research. The papers will be published (1977?) in the *Philosophical Transactions of the Royal Society of London*. Australian contributors at the meeting included D. Hopley, P. Flood, G.R. Orme, R. McLean, J. Veron, and B. Thom. P.J. Davies and J. Marshall also attended.

NATURAL HAZARDS SYMPOSIUM

MAY 1976, CANBERRA

The object of this conference was to bring together a cross-section of the community to discuss natural hazards in Australia. Natural hazards were defined as extreme geophysical events such as tropical cyclones, earthquakes, drought, etc. The conference was jointly sponsored by the Academy of Science, Academy of Social Science and Institute of Australian Geographers. It was attended by a mixture of natural and social scientists, as well as those interested in disaster relief (e.g. Natural Disasters Organisation), social welfare and engineering. Of interest to Quaternarists were the papers which reviewed the occurrence of natural hazards in Australia.

B. Thom	Natural hazards and Quaternary climatic change
J. Gentilli	Atmospheric factors in disasters: an appraisal of their role in Australia
M.J. Coughlan *et al.*	Drought - a natural hazard
N.P. Cheney	Bushfire disasters in Australia, 1945 to 1975
D. Denham	Earthquake hazard in Australia
J. Oliver	Wind and storm hazard in Australia
I. Douglas	Floods in Australia

The Academy of Science will publish these papers (1977?) in one volume together with other symposium contributions.

Because it was specifically concerned with Quaternary phenomena in providing an historical perspective to natural hazards, the conclusion of Thom's paper is presented here:

Natural hazards and future climatic change

Australia occupies a latitudinal position where the interplay of atmospheric and oceanic forces results in a high degree of climatic variability compared to many localities in the northern hemisphere. The short-term variability of climate is associated with droughts, floods, intense coastal storms, etc. Australian history is characterized by such events so it is not improper to consider natural hazards as components of the "normal" climate. However, in Australia and elsewhere increasing population, plus the demand for food and economic growth, means that the impact of constant or normal variability of climate will get progressively worse!

Planning for the future should take into account not only the normal variability pattern, but also a change in this pattern which may be associated with a longer-term climatic trend or an abrupt change. Surely the design engineer wishes to know if the 100-year flood is likely to become a 20-year event! Tucker (1975) in reply to the question "are we in the middle of a significant trend?" replied "we don't know". Prediction of climatic trends requires different methods from those used in conventional weather forecasting. The number of variables involved is large, and as yet there is no method for establishing future trends (A.A.S. 1976). Many of the questions raised at the beginning of this paper must remain unanswered. We do not know if Little Ice Age conditions are imminent, nor do we know just what will be the long-term impact of human activities on climate. As a means for predicting future climates, continuing investigations must be directed towards understanding the mechanisms involved as well as establishing past and present trends. Such studies could provide us the information on whether our environment will in either the long-term or the short-term become more or less "hazardous".

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WILLANDRA LAKES SYMPOSIUM - STRATIGRAPHY AND ARCHAEOLOGY

On the 9th of July a one day 'mini symposium' was held at the ANU on work in progress at the Willandra Lakes. The aim was to draw together the many people from diverse disciplines engaged in research in the area for a semi-formal exchange of information.

The session opened with an account from Jim Bowler of the development of work at Mungo and some current ideas about environments there. This was followed by the presentation of some results of thesis work by Tony Dare-Edwards on pedology and John Magee on sedimentology. Palaeomagnetic work at the Willandra Lakes was represented by Mike McElhinney on archaeomagnetism and Charlie Barton on magnetostratigraphy. Terry Bell outlined a comparison between dates of hearths obtained by C^{14} and by thermoluminescence. In the afternoon Alan Thorne briefly outlined some problems associated with the small population size of the human remains. Wilfred Shawcross and Isobel McBryde presented interim reports on their archaeological investigations followed by some ideas from Mike McIntyre for his thesis research just begun.

The final hour and a half was taken up by general discussion which centered on problems associated with dating and on new directions for archaeological research.

Approximately 100 were in attendance throughout the day including many from outside Canberra.

John Magee

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RESEARCH REPORTS

BARRIER REEF STUDIES - CAPRICORN AND BUNKER REEFS

Between 8 September and 13 October, seven reefs in the Capricorn/Bunker Groups were studied by three members of BMR (P.J. Davies, J.F. Marshall, D. Foulstone) and visiting scientists from the University of Sydney (B. Thom), Macquarie University (A. Short), James Cook University (N. Harvey) and the Queensland Institute of Technology (K. Martin). The seven reefs studied were Wreck, Masthead, Sykes, One Tree, Lamont, Fitzroy and Fairfax. The objectives of the expedition were -

1. To define, by geophysical methods and underwater sampling, the depth, shape and age of the unconformity on which the present reefs rest.

2. To determine the effects of the present day hydraulic regime on the growth of the reefs.

3. To define the time framework of modern growth.

4. To study the physical and chemical changes involved in reef lithification processes.

5. To estimate the potential for metal accumulation of reef sediments and to determine the time sequences of removal and deposition of metals in the carbonate sequence.

The M.V. Escape was chartered from Gladstone to provide the platform for field studies. Subsurface rock samples were collected by scuba diving to depths of 65 ft using a hand-held pneumatic drill. The depth and shape of the unconformity on which the present reefs rest was determined by seismic refraction methods, and its extension between the reefs mapped by echo profiling. It is hoped that C^{14} and uranium-series dating methods will enable a precise correlation of the surfaces encountered beneath all the reefs studied.

The influence of the present day hydraulic regime on the growth and extension of the reefs was attempted by measuring the wave and current energy impinging on the reefs and its resultant dissipation. Laboratory experiments will determine the sediment load carried under different sets of hydraulic conditions.

The development of reef islands was studied by surveying methods. Laboratory analysis of rock samples will outline the timing and nature of the processes involved in the growth and destruction of the reef islands. A novel and rapid method of sediment sampling was employed in the lagoon of Fitzroy Reef. A diver was towed on a manta board between sample locations, and immediately dived at the predetermined site. Preliminary results from Echo profiling and seismic refraction suggest that the reefs of the Capricorn/Bunker Group rest on a hard indurated karst surface, the depth of which varies from reef to reef.

A paper on the evolution of One Tree Reef was published in the BMR Journal during the year (Davies, P.J., B.M. Radke and C.R. Robison 1976, The evolution of One Tree Reef, South Great Barrier Reef, Queensland. *BMR J. Aust. Geol. Geophys.* 1, 246-247).

P.J. Davies
Bureau of Mineral Resources

INVESTIGATIONS OF LATE PLEISTOCENE CAVE DEPOSITS IN TASMANIA

Geomorphologist Albert Goede and I formed an interdisciplinary team early in 1975 in order to examine a large number of Tasmanian Pleistocene Cave deposits containing large quantities of faunal material. Our investigations began with a series of small cave systems developed in low isolated outcrops of the Duck River Dolomite ('Montagu Karst') located near Smithton, Northwestern Tasmania.

Three caves containing fossil mammal remains were located and subsequently sampled. Each system appears to have a slightly different, perhaps overlapping faunal assemblage, but all appear to be within the last hemicycle of the last glaciation in age.

Cave MU-206 is characterised by three strata of fossiliferous fill. Fossil bone is poorly preserved in the fine, highly organic silt of the lowest stratum. Bed 2 is an angular dolomite breccia containing remains of *Thylogale*, *Macropus rufogriseus*, *Palorchestes*, a few small mammals and birds. Bed 3 is a widely dispersed fan of cave fill that originated from a steeply inclined shaft leading to the surface. It contains fewer, more rounded dolomite fragments than Bed 2. *Thylogale*, *Sthenurus (Simosthenurus)* sp. and *Perameles* are very common. *Macropus rufogriseus*, *Macropus titan* and *Protemnodon* sp. are present in smaller numbers. Rare assignments include *Thylacoleo carnifex*, *Thylacinus*, *Sarcophilus*, *Arctocephalus*, *Zaglossus*, Unidentified Diprotodontidae, *Vombatus ursinus*, *Mastacomys fuscus* and *Hydromys*.

A radiocarbon date on bone collagen from materials in Bed 3B suggests a minimum age of 10,000 years BP. Goede, in collaboration with Russ Harmon of Michigan State university, has employed Uranium/Thorium decay to date stalactites incorporated in the Bed 2 breccia. Results obtained so far tend to substantiate a post-glacial maximum age for Bed 3.

The other Montagu Caves, Main Cave (MU-201-202) and MU-203-205, are undated and as yet unexcavated. A small sample of 242 elements from Main Cave is composed of *Macropus rufogriseus*, *Thylogale*, a single left $M^{\overline{3}}$ of *Sthenurus (Simosthenurus)* sp., *Perameles*, *Pseudocheirus* and *Zaglossus* sp. MU-203-205 consists primarily of *Macropus ?titan* and *Macropus rufogriseus* remains.

Several assemblages from the Florentine Valley in Central Southwestern Tasmania are currently being analysed. Beginner's Luck Cave contains an archaeological horizon within an angular limestone breccia dated from associated charcoal to 12,000 ± 200 years BP (R5001/4). A deposit in another chamber of the same cave contains *Sthenurus (Simosthenurus)* sp., *Dromaius*, and *Macropus rufogriseus*. Bone collagen from this material yielded a radiocarbon determination of 14,450 ± 250 years BP (R5001/3).

Nearby Boomer Cave (JF-91) is a trap containing *Macropus titan*, *M. rufogriseus* and *Dasyurus*. Titan Cave (JF-97) has so far yielded more than 10,000 specimens of highly fragmented fossil material. Species identified so far include *Protemnodon*, *Sthenurus*, *Macropus titan*, *M. rufogriseus*, *Dasyurus* and *Sarcophilus*. Charcoal and burned bone is present in the fossil horizon.

Descriptions of these sites and the material in them are in press in the following journals:

Murray, P. and A. Goede — Pleistocene vertebrate remains from a cave near Montagu, Northwest Tasmania. *Rec. Queen Victoria Museum, Launceston*

Goede, A. and P. Murray — Pleistocene man in south central Tasmania: evidence from a Florentine Valley cave site. *Mankind*

Peter Murray
Tasmanian Museum and Art Gallery

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QUATERNARY SHORELINES

1974-1976 Research on Quaternary Shorelines in Australia and New Zealand - a summary report of the ANZAAS Quaternary Shorelines Committee

Introduction

Continued research on Quaternary shorelines in the Australasian region is indicated in this report. Greater detail is being obtained on Holocene sea levels and regional variations in the evidence viewed less sceptically. Further evidence of sea levels of the last interglacial and of the lowered levels of the last glacial is completing the detail of the last 120,000 years. An encouraging aspect of the research being undertaken is the emphasis put on present processes in explaining the evidence of the past.

David Hopley
Honorary Secretary

NEW SOUTH WALES

Ongoing research

Mr E.A. Bryant (Macquarie University) is continuing his research on beach fabrics with respect to wave processes, and Mr R.W. Kidd is following up his work on sedimentary budgets in New South Wales coastal inlets. Professor J.L. Davies is engaged on a long-term project delineating different coastal environments throughout Australia, including work on shore platforms with respect to a number of variables. New research at Macquarie since the last Report includes one project by Dr Andrew Short on the offshore dynamics of Narrabeen Beach, Sydney, and another by Miss Lorraine Oak on the dynamics of boulder beaches.

Dr Bernard Swan of the University of New England, following up work carried out in 1966 by Langford-Smith and Hails, has completed a project on depositional evidence for higher sea levels on the New South Wales coast. He found rounded beach type pebbles and exogenous sand at elevations up to 48 metres above mean sea level.

At the Australian National University Dr R.F. McLean and Dr B.G. Thom (who has since moved to the Department of Geography, R.M.C., Duntroon) have continued their work on beach changes at Moruya, on the South Coast. Close monitoring of profiles (e.g. every two weeks) has been shown to be essential for an adequate interpretation of the mechanism of beach change. Results have

substantiated earlier findings that change from any one storm is strongly influenced by the particular state of the beach at the onset of the storm.

Dr Peter Roy and Ms E.A. Crawford of the New South Wales Geological Survey (Department of Mines) have been active on various parts of the New South Wales coast. They have been concerned with estuarine investigations at Port Stephens, involving stratigraphy, bottom sediment, and hydrodynamics; trace metal investigation of the bottom sediments in Lake Macquarie (jointly with State Fisheries); and sediment transport in the lower (navigable) sectors of major coastal rivers from the Tweed to the Hunter, in relation to the coastal sediment budget. They have also been working on bed changes in the lower Wooli River; on Towra Point erosion in Botany Bay (with Mr N. Lawson of the Maritime Services Board, and officers from State Fisheries); and aspects of the geomorphology of Kurnell Peninsula.

A comprehensive three-year study involving Dr L.D. Wright (University of Sydney), Dr J. Chappell (ANU), and Dr B.G. Thom and Professor T. Langford-Smith (University of Sydney) has been initiated under an ARGC grant. The aim is to investigate the processes responsible for the characteristic patterns of sediment transport, deposition, and erosion on the southern and central New South Wales coast, and to identify causal links between waves and currents and shore-zone and near-shore morphologies. Factors being examined include wave energy regime; wind, wave, and tide induced current processes of near-shore compartments; wave spectra, beat phenomena, and edge waves; and sediment exchange between adjacent nearshore systems and estuaries. Dr Wright has also embarked on a study of the sedimentary dynamics of the Shoalhaven River mouth, involving monitoring the effluent dynamics and morphological changes. Drs Wright and Thom are also involved in a study of the depositional history of the Shoalhaven Delta.

Mr G. Bowman (University of Sydney) is continuing his research on podzolization in Holocene and barrier systems. Extensive C^{14} dating of these deposits has made it possible to determine the age of many podzol profiles; and by sampling profiles of known age (but subject to different environmental influences) the effects of variations in each of the soil forming factors are being isolated and measured. The objective is to obtain a quantitative model of podzol development and to ascertain more about the evolution of the New South Wales Holocene barriers.

Mr D.M. Chapman (University of Sydney) has been engaged on a sand tracer experiment north of the Tweed River in conjunction with the Gold Coast City Council. The aim of the experiment in the first instance is to study sand movement on Kirra Beach. Approximately 38,000 kg of dyed sand was injected continuously into the littoral system over a period of three weeks, and subsequently sampled using three dimensional survey and sampling techniques developed for the experiment. Analysis of the samples and survey data is now in progress.

In another long-term project, Dr B.G. Thom (University of Sydney) is running transects across the Inner and Outer Barrier systems of New South Wales to gain new evidence on the mode and time of formation. In a paper recently published (*Nature* 263, 120-121), Marshall and Thom report $^{230}Th/^{234}U$ dates for corals from within the Inner Barrier at Evans Head and near Newcastle. It is suggested that this deposit is a Last Interglacial event.

T. Langford-Smith

NEW ZEALAND

Postglacial progradation

Armon[1] considered that the Kaikorete Barrier, enclosing Lake Ellesmere, commenced about 6000 to 7000 years ago, during rising sea level, from sediment supplied by longshore drift from an eroding coastline to the south-west. Sea level may have been up to 1.5 m above present level during the later stages of formation. No firm date can be placed on the commencement of this feature. Similarly no firm date can be placed on the commencement of a postglacial dune belt on the ocean side of the South Kaipara Barrier but Schofield[2,3] considers that like other dated progradational features of Holocene age in the Auckland region this prograded region commenced about 4000 years ago and has developed as a result of an overall fall in sea level. Once again longshore drift is an important factor, some sand for this Kaipara dune belt being derived from as far south as Mt Egmont. More importantly, from lack of sufficient supply from the hinterland, and from identical mineralogies it is shown that this Kaipara dune belt has been almost wholly derived from the sea floor. There are five periods of deposition within the dune belt, their volumes being a direct linear function of the net sea level fall at the times of their formation.

The transformation from an estuarine to a lacustrine environment in the Lower Wairarapa is described by Leach and Anderson.[13] They conclude that, 'The most likely explanation ... is extensive late Holocene alluviation, although retreat from higher postglacial sea levels, or local tectonic events, cannot be ruled out as contributing factors.'

Transport along the Continental Shelf

Carter and Heath[4] concluded that during a '25-y storm' waves have the potential to stir sediment down to depths of 130 m. They concluded that, 'Optimum conditions for transport probably occur during storm periods when wave-suspended sediment is readily moved by tides and the mean circulation.'

'The direction of transport is mainly along the continental shelf and is largely in response to prevailing weather patterns coincident with the direction of the mean circulation and strongly reinforced by the appropriate phase of the tide.'

These views agree with the conclusion of Lewis and Eade[14] 'modern sediments blanket much of a narrow 10-30 km wide zone close to the (Taranaki) shore ... At other places sediments were deposited when the sea was lower ... although these sediments may have been subsequently resorted by waves and currents.' It also agrees with conclusions derived from a mineralogical and volumetric study of the South Kaipara postglacial dune belt (Schofield[23]), namely, that the local sea floor profile of equilibrium probably extends to depths of between 80 and 120 m, and that the offshore coarse belt, between about 50 and 100 m, is a modern lag deposit formed during the last 4000 years. The absence of black sand concentrates is further evidence that this offshore, coarse sand belt is not a relict beach formed when sea level was lower.

Descriptions of offshore sediments for three small areas are given by Carter[3], Carter and Ridgway[5] and McDougall.[15]

Coastal change

Kirk[12] found, from a study of two periods of aerial photography that between 1942 and 1974 there have been large variations in the rate of shoreline change within short distances. 'These variations are thought to reflect local differences in the availability of sediments in the littoral zone and the longshore distribution of dominantly high energy wave action ... the weighted mean accretion rate (0.39 m/year) has been much higher than the weighted mean rate of erosion (-0.26 m/year).'

Regular surveys during 1965 to 1968 of three beaches in three energy environments (Schofield[22]) show that there are close relationships between an empirical wind-energy curve, beach change and sea level change. Whereas sea level rise promotes coastal erosion, its fall promotes coastal progradation. Predictably, the greatest seasonal changes took place along the most exposed beach but the 'sea-floor equilibrium profile is also a function of energy input; there is a direct relationship between maximum depth of profile and magnitude of beach change.' Offshore removal of sand within the zone of sea-floor equilibrium promotes erosion and although local dredging has since ceased, its erosive effect on the local coast may continue for many years.

Pre-Holocene sea levels

Many assumptions are involved in correlations of terrace sequences on both coasts of the North Island (Chappell[6,7]; Mildenhall and Harris[17]). There is no doubt that tilting is an important factor but the interpretation that the Northland-Auckland region has been epeirogenically uplifted is not proven.

From a study of marine terraces at Cape Terawhiti and Tongue Point, Wellington, Heine[10] reaches the conclusions, 'that there is no evidence on this coastline for a westward tilt of the magnitude previously inferred, and that it is necessary to recognise distinct levels at 125 ft (38 m), 150 ft (46 m), 240-250 ft (73-76 m), c.400 ft (122 m), and c.480 ft (146 m).'

Of three terraces in South Westland, Knights Point Terrace (140-147 m), Sardine-1 Terrace (55-60 m) and Sardine-2 Terrace (24-32 m), the first and last are 'underlain by marine sediments deposited during interglacial high stands of sea level' (Nathan[18]). From 10 conflicting radiocarbon dates it is concluded that all terraces are older than 40,000 years and that all dated material has been contaminated by younger carbon. A sequence of pollen samples from a peat bed at the base of the marine sequence in Sardine-2 Terrace shows a change towards milder climate (Moar[16]).

Coastal hydrology

A number of papers on coastal hydrology have appeared in the New Zealand Journal of Marine and Freshwater Research. Two of these contain information of interest to coastal sedimentologists. Booth[2] concludes that at least the surface water in the Bay of Islands circulates in an anti-clockwise direction. Heath[9] examines the relation of tidal compartments to entrance cross-sectional area for 20 coastal inlets. 'Sixteen inlets conform to a linear relationship, which is consistent with stable entrances the sizes of which are determined by the ability of the tidal flow to transport sediment. Based on this criterion deposition should be taking place at the entrances of the other four inlets: Wellington, Lyttelton and Akaroa harbours, and Paterson Inlet. Available data confirm this for Wellington and Lyttelton Harbours.'

General

The Royal Society of New Zealand Bulletin 13, 'Quaternary Studies' published in 1975, contains selected papers from the IX INQUA Congress, Christchurch, New Zealand, 1973 - Fleming's[8] 'The Quaternary Record in Australia and New Zealand' provides a useful summary; Jardine's[11] 'The determination of former sea levels in areas of large tidal range' is of particular interest, as is the summary of Madame Ters[24] 'Variations in sea level on the French Atlantic Coast over the last 10,000 years.' Unfortunately the time scale for the French curve in Ters[24] is incorrect; the correct curve is in Ters[25]. The French curve is in terms of calendar years and when the secondary transgressions of the northern New Zealand curve (Schofield[21]) are converted to calendar years there is a fair degree of correlation with those on the French curve.

A further useful summary of Quaternary events within New Zealand is provided by the Quaternary Geology Map of New Zealand (New Zealand Geological Survey[19,20]).

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QUEENSLAND

Published work (including in press)

1. North Stradbroke Island

G. Benussi has reviewed the genesis of North Stradbroke Island (1975). The island has formed from large quantities of sand of fluvial origin from the eastern Australian highlands and carried northwards by longshore currents. Three main stages of dune building are recognised related to glacial periods and lowering of sea level.

2. Broad Sound

In press are results of the BMR survey of the Broad Sound area led by P.J. Cook. Two bulletins by P.J. Cook and W. Mays deal with:

i) Sedimentology and Holocene history of a tropical estuary (Broad Sound, Queensland)

ii) Geochemistry of Broad Sound and its sediments

A cooperative study by P.J. Cook and P. Blattner (DSIR, New Zealand) on the isotope and trace element chemistry of shells from Broad Sound Holocene cheniers is in preparation.

3. Gulf of Carpentaria

The BMR Gulf of Carpentaria survey team (H.F. Doutch) is writing up a number of reports and papers relevant to the Quaternary history of the Gulf.

4. Moreton Bay

Hekel *et al.* (1976) report preliminary results from continuous seismic reflection profiling which indicate that large areas of Moreton Bay are devoid of present day sediments. The development of several erosion surfaces during Pleistocene low sea level stands is inferred. Drowned intertidal terraces at depths of -4, -7 and -20 m relative to LW Datum have been identified. Also in Moreton Bay, Lovell (1975) has given further details of the controversial raised(?) reef on Pell Island and also describes a 2 m raised beach rock of mid-Holocene age on nearby St Helena Island.

5. North Queensland

Hopley (1975) has reviewed the variable evidence for Holocene sea levels on the Bowen-Whitsunday coast. Maximum elevations range from 0 to 3.7 m. Reasons for such variation both here and worldwide are discussed and may be related to mismeasurement or misinterpretation of the evidence, real variations in sea levels related to tidal or other oceanographic variation through time or tectonic or isostatic movement of the land. A hydro-isostatic warping of the shelf is favoured.

Hopley and Murtha (1975) discuss the Quaternary deposits of the coastal plain near Townsville. The chronology is related to sea levels since the Last Interglacial.

6. Great Barrier Reef

Results of the 1973 Royal Society-Universities of Queensland Expedition to the Great Barrier Reef led by Dr D.R. Stoddart were presented at the Royal Society in London in January 1976, and are to be published in the journals of the Royal Society.

Results of relevance to Quaternary shorelines include the identification of two marked disconformities lying beneath sediments and reefs of the marginal shelf identified by continuous high resolution seismic profiling, at 66 m and 81 m near Spur Reef but rise towards the inner shelf (Orme, G.R., J.P. Webb, N.C. Kelland and G.E.G. Sargent). The shallow structure of reefs was indicated by drilling on Bewick and Stapleton Reefs (Thom, B.G. and G.R. Orme). Data suggest three or four disconformities at Bewick, the youngest at c.3-4 m below L.W.M. separating Holocene from pre-Holocene reef carbonates. More specific sea level studies based on the geomorphology of the low wooded islands (Stoddart, D.R., R.F. McLean, D. Hopley, H. Polach and T.P. Scoffin) suggest that present sea level was reached on these inner margin reefs about 6000 y BP. Oscillations of sea level since that date are identified with varying degrees of confidence but a higher level up to 1 m may be present.

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Hopley, D. and G.G. Murtha 1975 The Quaternary deposits of the Townsville coastal plain. James Cook University, Department of Geography *Monograph Series* 8, 30 pp.

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Work in progress

Mr A. Belperio (Department of Geology, James Cook University) is currently undertaking postgraduate research in the coastal marine processes and patterns around Townsville. C^{14} dates are providing the basis for coastal accretion rates and providing information on Holocene sea level.

Mr N. Harvey (Department of Geography, James Cook University) is investigating the nature of the pre-Holocene karst surface beneath the Holocene veneer of reefs of the Great Barrier Reef in the Townsville and Cooktown areas. A related program from the same department (Associate Professor D. Hopley) is gathering information on sea levels and hydroisostasy from the continental shelf by way of shallow coring of Great Barrier Reefs.

Information is being collated on earlier deep cores from the fringing reef on Hayman Island (Hopley and Smith, James Cook University and McLean and Marshall, Australian National University. Dating includes 13 C^{14} dates (one background date from the pre-Holocene surface and a series of Holocene dates back to 9320 years) and one U series date. A sea level curve from the site is being constructed.

D. Hopley

NORTHERN TERRITORY

Work in progress includes that of M. Williams, M. Clark and R. Wallom on the Point Stuart chenier plains.

M. Williams

TASMANIA

Bass Strait coasts

1. Smithton - Mella - Pulbeena areas

Examination of the extensive Late Pleistocene raised beaches is being continued by G. van de Geer.

2. Laycocks Beach, Devonport

Carbonised twigs and charcoal from the top of a shallow lagoon deposit overriden by a dolerite shingle beach have yielded a date of 5990 ± 260 BP (GaK-5618). An artifact was found in the deposit, 1.7 m above high water springs. Laycocks Beach was incorrectly called Coles Beach (actually the next beach to the west) in the 1971-72 shorelines report (Chick, 1972).

3. Estuarine terraces and raised shingle beaches

At the mouth of the Forth River interglacial sediments have been recorded up to 16 m above OHWM and occur within the area glaciated during the Forth Glaciation (Colhoun, in press). Ice limits approached Latrobe in the Mersey system and reached the Level river estuary. The Last Interglacial raised beaches from Lodders Point to Point Sorell were built largely of sediments derived from glacigenic deposits at or near present sea level. Between Ulverstone and West Head, estuarine terraces, raised beaches, and shore platforms, caves and stacks have been mapped by N.K. Chick, and rise to a maximum of 22 m.

4. Badger Beach and West Head

Freshwater peat with wood, exposed at mid-tide level 2 km from the west end of Badger Beach and at high tide mark, 2.75 km from the west end, have yielded dates of 7850 ± 140 BP and 8020 ± 140 BP (GaK-5620 and GaK-5621). At West Head, black plastic organic clay, the A1 horizon of a podsol developed on Last Interglacial marine sands now buried beneath Holocene transgressive dunes, has given a date of 15,900 ± 510 BP (GaK-5619). To the west, this soil profile was deflated prior to the Holocene transgression.

5. Northeast coastal plains

Between Bridport and Eddystone Point, the hydrology and geomorphology of the coastal plains are under investigation by A. Bowden. Thicknesses and limits of Late Pleistocene sands, lake deposits and lunettes have been mapped, and the wind vectors associated with several generations of linear and parabolic dunes determined.

West Coast

N.K. Chick has examined erosional shorelines and deposits of Last Interglacial age between Trial Harbour and Macquarie Heads at heights of 1.8, 4-5, 8-12 and 18-22 m. Terraces above this height at Strahan (Davies, 1960) are thought to be glacigenic, and are being investigated by E.A. Colhoun and N.K. Chick. Most of the shoreline evidence is obscured by transgressive dunes, rising to a maximum height of 145 m. At Strahan airport, the Last Interglacial raised beach beds at 22 m have cryoturbation type structures in the top 1 m indicating deep winter freezing of the soil during the Last Glacial stage.

East Coast

The coast between Chain of Lagoons and The Friendly Beaches has been examined by N.K. Chick. Last Interglacial beach sands and gravels at sea level at Denison River show cryoturbation structures like those at Strahan (Colhoun, pers. comm.). At Harmans Creek, the Last Interglacial cliff and beach are cut into an older alluvial fan, and buried by another fan of Last Glacial age. Coarse river mouth gravels of possible Penultimate Glacial age have been overridden by the Last Interglacial sea at Douglas River. Last Interglacial shorelines range up to 21 m in altitude.

N.K. Chick

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VICTORIA

Part 1 published work

Bird (1973 has his paper on *Australian Coastal Barriers* reprinted in *Barrier Islands* (ed. M.L. Schwarz) Benchmark Papers in Geology 9:132-141. He has also discussed the origin of the Nepean Bay Bar in Port Phillip, a biocalcarenite structure (Bird 1975). Bird and Barson (1975) contributed a paper to the Royal Society of Victoria's Symposium on Westernport concerning the shoreline changes that have occurred since European settlement. Reinson (1975) discussed the geochemistry of the muds in the restricted shallow estuary of the Genoa River in East Victoria. Gill (1975a) discussed examples of coastal erosion and deposition. He has also described (1975b) a succession of Last Interglacial and Postglacial calcretes in the Warrnambool and Port Fairy districts of Western Victoria, and dated them by U/Th and C^{14}. A 55-page report on the *Coasts of Australia* (Gill, 1975c) was prepared as an appendix to a report by Dr G.D. Aitchison entitled 'A preliminary appraisal from the viewpoint of geomechanics of national needs for research and development in coastal and offshore engineering (and in the related earth sciences)'. The coastal report classifies the coasts of Australia, describes them, reviews the literature, and provides new information. Gill and Amin (1975) showed by stratigraphy and U/Th dating that there is a 4 m stage of about 110,000 y BP in the retreat of the Last Interglacial sea. Gill (1976a) discussed the quantitative approach to the study of coastal sediments.

Part 2 new research

The Woodbine Basalt at Port Fairy in Western Victoria is Penultimate Glacial in age (dated c.300,000 y by K/Ar), extending 30 m below present sea level at the present coast. The original surface of the basalt consisted of tumuli, collapsed lava tunnels, lava ridges, collapsed tumuli, and such so that when the sea advanced over this varied terrain in the Last Interglacial, there were many different facies - bays, seaways, rock platforms, boulder beaches, sand beaches, lagoonal beds, estuarine beds and so on. A new and unusual facies has now come to light in a quarry on the west side of Hummocks Road at Yambuk, northwest of Port Fairy, where Quaternary calcarenite overlies Miocene marine limestone. The following section has been studied, and is referred to the Last Interglacial:

0.5 m	Terra rossa formed in top of
1.25	Calcarenite slabs in calcarenite sand
0.2	Calcarenite sand
0.12	Silty sand with numerous shells of the euryhaline gastropod *Potomopyrgus* plus fragments of shallow water marine shells
0.23	Fine calcarenite
0.15	Red silty fine sand (paleosol) merging into gray ditto with *Ostrea sinuata* shells
1+m	Breccia as at surface

The breccias at the top and bottom indicate a comparatively high energy environment, resulting in strong erosion. The lower breccia also includes some pieces of terra rossa. The palaeosol in the middle of the cycle marks the limit of marine encroachment. The *Potomopyrgus* (det. Dr B.J. Smith) bed indicates a back-beach pond or lagoon, while the oysters under the palaeosol indicate a shallow water marine environment.

In the Department of Geography, University of Melbourne, information on Quaternary shorelines is being obtained in the course of research on coastal dunes in East Gippsland (N.J. Rosengren), the tidal watershed in Westernport Bay (I. Miles), and the west coast of Port Phillip Bay (C. Symons). Studies of shoreline evolution on a number of sectors of Westernport Bay have indicated evidence of a slight emergence in Holocene times, for example at Palmer Point (Kraemers 1975), and the Late Quaternary evolution of the Nepean Peninsula has been reviewed by Bird (1975). The Victorian Town and Country Planning Board is currently preparing a detailed study of coastal scientific areas, including geological and geomorphological sites where information relevant to Late Quaternary history has been, or is likely to be, obtained.

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Geochronology

In recent years the geochronology of the Quaternary shorelines of Victoria has been considerably extended, and so a review and interpretation is now desirable. The Plio-Pleistocene boundary has been studied extensively in the Portland/Nelson region, and so the K/Ar basalt dates at Portland provide a valuable time marker for the local stratigraphy (Aziz-Ur-Rahman and McDougall, 1973; Singleton, McDougall and Mallet, 1973; Gill, 1976b). At Geelong, another coastal town, basalts have been dated 1.8 - 2.11 m.y. (Aziz-Ur-Rahman and McDougall 1973, Mines Department map), so providing a datum for the local Quaternary sequence.

At Warrnambool in Western Victoria, the Yangery Basalt at the back of the embayment filled with dune, beach and shallow water calcarenites has been dated 1.9 and 2.0 m.y., showing that the whole calcarenite sequence is Quaternary (McDougall and Gill, 1975). At nearby Port Fairy the Penultimate Glacial Woodbine Basalt has been dated 301,000 y in the town and 312,000 y at Cape Reamur, 8 km to the west (McDougall and Gill, 1975). The Last Interglacial 7.5 m sea level was dated 125,000 yr by Valentine (Gill 1967), while a 4 m stage of marine retreat has been dated about 107,920 y (Gill and Amin 1975). The same authors have dated the Penultimate Interglacial at Warrnambool (sample from east bank of the Hopkins estuary) at about 400,000 y.

In East Victoria, a shell bed revealed by a drain near Sale dated 101,000 y, but it does not mark a shoreline and is interpreted as part of the Last Interglacial retreat (Schornick 1974; Gill 1974). When the sea had finally retreated from the Last Interglacial high sea level, a terra rossa developed on calcareous sediments and a mature podsol on the siliceous beds. On the calcarenite sequence at Warrnambool/Port Fairy a terra rosa developed with a calcrete subsoil 0.5 - 2 m thick. Erosion on the coast of these deposits after the Flandrian Transgression has revealed numerous rhizomorphs. Near Cape Reamur, rhizomorphs of compact ringing calcite dated 20,350 y by C^{14}. A Holocene set of rhizomorph-like structures (Gill 1975b, pl.8, fig.1) dated 8790 y. A finely lamellar mammilary calcrete deposited on top of the terra rossa calcrete hardpan dated 8700 y, and is overlain by the Tower Hill tuff dated 7300 y.

At Tower Hill beach, overlying the bedded tuff and underlying two sand ridges, is an ancient sand flat with an extensive Aboriginal midden and tool-making site, the lower part of which dated 5120 y (charcoal) and the upper part 4315 y (marine shells). A midden in the soil overlying the sand ridges dated 2800 y. Other datings of this soil on Holocene dunes and sand ridges in this region range from 2620 to 3080 y (Gill 1973, 1976c).

Radiocarbon dates for Holocene oscillations of sea level evidenced by emerged marine shell beds along this coast cluster round peaks of 6000, 4000, 2850 and 750 y (Gill 1967, 1976c).

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