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QUATERNARY AUSTRALASIA, VOL. 13/1, JULY 1995

Material for the next issue should reach the editor by **30th September 1995**:

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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 journal *Quaternary Australasia* twice a year. *Quaternary Australasia* is edited by Bill Boyd, with assistance from Colin Murray-Wallace. The annual subscription is $A20 or $10 for students, unemployed or retired persons. President 1993 - 1995 is Dr Ian Thomas, Department of Geography, University of Melbourne. An application form for membership is appended to this issue (last page), and should be returned to Dr Geoff Hope, Membership Secretary, Division of Archaeology and Natural History, Research School of Pacific and Asian Studies, Australian National University, Canberra, 0200. Members joining after September gain membership for the following year. Existing members will be sent a reminder in December.

COMMITTEE MEMBERS

QUATERNARY AUSTRALASIA, VOL. 13/1, JULY 1995

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EDITORIAL

Volume 13/1 ... a bit later than planned, but nevertheless here at last. You'll never guess the source of tardiness, I'm sure. I put it down to editor's optimism! Optimism, that is, that papers will come rolling in, and that we'll have another fat(tish) volume. My hearty thanks to those who have contributed, and enthusiastic encouragement to everyone else who has something to say about the Quaternary, but has felt too shy to send the something to *Quaternary Australasia*. Remember, this is your journal, and if anyone should know about your work or opinions regarding the Quaternary of this region, then this is the place to let them know! That's enough of that ... I think you get the general idea.

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The Quaternary community in Australia and New Zealand has, I suspect, something of an ageing population. We hear of some of our slightly older colleagues being appointed to Professorial positions around the traps (I'll not take the risk of naming names, in case I offend my omission, but offer my congratulations all round anyway). We also hear of retirals -- Albert Goede has his last shot as the much valued and appreciated AQUA treasurer in this issue -- and, sadly, deaths. I note the passing of Jerry van Tets, and I am sure that many AQUA members share my feeling of loss for a person who provided valuable input to our search for understanding of the past. I am also continually aware, however, of the arrival of a younger generation of exciting and, I trust, excited, Quaternarists. I have recently had the pleasure of interviewing several of our up-and-coming researchers for all-too-few positions, and of examining Ph.D. theses which clearly point the way to a productive future. Clearly the University system in this region is producing a crop of high quality young Quaternarists. Let us hope we can keep them in the system.

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This last point brings me to my next suggestion. At this time, I think it would be most valuable, both for practising Quaternary scientists and our students, to review the place of Quaternary teaching in our undergraduate and postgraduate courses ... and this is where I come to some questions: Where are our undergraduates and postgraduates studying? What are they learning? Who is teaching them? Where? What? (... and even Why??).

Having just filled out a questionnaire asking similar questions with regards to teaching within another discipline, I am strongly resisting the temptation to draw one up here for you to fill in. Instead, all I ask is that you write to me describing the Quaternary teaching that you and your colleagues get up to, what you teach, to whom, at what level, and anything else your think may be useful. I'll happily receive course or unit outlines or pamphlets, and if you want to dob in a colleague who may be reluctant to answering such requests (they may not have read this, of course!), please feel free to. If you want to make life easy for yourself, and you are on e-mail, send a message to me at bboyd@scu.edu.au. I will collate responses, and if it looks like we have a reasonably representative sample of Quaternary teaching in Australia and New Zealand (how does one define a "representative sample" in this context?) and will produce a preliminary guide to Quaternary teaching in the region. The optimist in me suggests that such a guide will appear in the next issue of *Quaternary Australasia* ... so hurry with your letters. If responses are slow, I may well mail you all, this time with a real questionnaire form to be filled in. You have been warned!

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Before I finish, I draw your attention to the President's report. In it Ian raises some important issues for discussion regarding the Quaternary community and AQUA, especially with respect to the future role or roles of AQUA. We do not yet have any answers for the questions he raises, and need as much input from members of the Association. Any comments of opinions concerning the future of AQUA will be gratefully received.

That's all folks!

Bill Boyd, Editor.

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AUSTRALIAN QUATERNARY ASSOCIATION

PRESIDENT'S REPORT

A NEW DIRECTION FOR AQUA?

At a recent meeting of the National Committee for Quaternary Research at the Australian Academy of Science a number of suggestions were made which have direct implications for AQUA and its members. The committee felt that Quaternary researchers in Australia needed to be more involved in decisions which are presently being made at the national level. It was noted that groups such as the archaeologists and palaeontologists needed to be drawn into the wide ranging discussions which take place at the Academy and which are likely to have some impact on those disciplines.

The prime concerns of the National Committee are to foster and maintain international links, while AQUA is seen strictly as a national body which aims to encourage young researchers and to provide opportunities for scientists to meet each other at least bi-annually. This division can, and has, led to a lack of cohesion in terms of organising meetings, workshops and conferences. The recent debacle in regard to CLIMANZ is an example of how a lack of organisational focus can result in the loss of opportunities.

Our newsletter needs more support. We can afford to publish more often, but our editor, Bill Boyd, needs more support and resources. It may be that we need to look at a vehicle which can disseminate information rather more quickly than occurs at present? We need to ask members what they want from AQUA in terms of access to information. Do we need to set up a home page on the World Wide Web for instance? Would that obviate the need to alter the current publishing schedule?

The National Committee usually meets annually or under special circumstances. Much of their business is taken up with INQUA programmes. Is there a role for AQUA in the co-ordination of meetings and affairs which fall between National Committee meetings? Are members happy with AQUA taking a more central role in the planning and organisation of Quaternary interests up to and including international matters?

We also need to consider the implications of our name. It has come to my attention that our Kiwi membership is very low. Why is this? What can we do to maintain our single international connection? Should we explore the possibility of reciprocal membership rights with other organisations such as SASQUA in South Africa. There are also possibilities in Indonesia, Malaysia and other southeast Asian countries.

Rather than ignore the New Zealand question, perhaps we should expand our influence so that AQUA has input into research programmes, field work and meetings at a genuine regional level?

At this point I would like to ask members to forward their views to committee members in regard to these issues. If the AQUA committee can reach agreement, it may be possible to set up a structure which can act as a real focus for Quaternary research in the region. As long as some of the fun and spontaneity which characterises AQUA at present remains, I can see no reason why we cannot develop our organisation to a level where good science can be combined with easy access and increased research and social opportunities.

Ian Thomas
President, AQUA.

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AUSTRALIAN QUATERNARY ASSOCIATION

TREASURER'S REPORT FOR 1994

This is my final report after nine years as Treasurer. The financial statement for 1994 does not give a true impression of the Association's finances for 1994 as the cost of printing and postage of *Quaternary Australasia* 12/2, nearly $2000, had not yet been paid when the books were closed and the funds transferred to Melbourne.

Receipts in 1994 were down marginally on the previous year. Income from subscriptions increased somewhat but income from interest was significantly lower due to all funds having to be kept in the general account prior to transfer to Melbourne instead of most of the money being kept on term deposit.

Payments, even when the nearly $2000 still to be paid for *Quaternary Australasia* 12/2 is taken into account, is still significantly lower than in 1993 when the Association provided substantial financial support to the Inter-INQUA and Palaeolimnology Conferences held in Canberra.

Our membership continues to grow slowly and the continued inclusion of membership forms in the journal has played an important role in this.

The Association remains in a very secure financial situation and can look forward to another active and successful year.

My commiserations to Christine Kenyon who has taken over as Honorary Treasurer. I wish her all the best in an important task necessary to keep AQUA financially secure into the future.

Yours sincerely,

Albert Goede
Retiring Treasurer of AQUA.

Australasian Quaternary Association

Statement of receipts and payments from 1st January 1994 to 2nd December 1994

Uncommitted balance brought forward from 1993	23,207.61CR
Add Receipts	
Subscriptions:	
Personal (1993)	40.00
Personal (1994)	3,273.70
Personal (1995)	30.00
Institutional (1994)	448.87
Institutional (1995)	60.00
Interest: Bank & Credit Union	1,012.63
Sale of publications	50.00
	4,915.20
Deduct Payments	
Printing costs	960.00
Duties and taxes	24.51
Postage	457.35
Student prizes	1,000.00
PO Box	75.00
Dishonoured cheque	21.00
Stationary	20.60
	2,558.46
	2,558.46
Excess payments over receipts	2,356.74
	2,356.74CR
Bank balance as at 2nd Dec. 1994	25,564.35CR
Transfer of funds to Melbourne: Cheque dated 31st July 1994	2,000.00
Remaining funds transfer, 2nd Dec. 1994	23,564.35
	25,564.35CR

Signed

Albert Goede,
Honorary Treasurer, AQUA

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INQUA

Executive meeting, Kathmandu

The following are notes provided by Jim Bowler, as information to (and I quote) "Members of the National Committee, Quaternary Research, AQUA Executive, Any others interested?" As editor, I take that to mean any member of AQUA ... so here goes.

From: Jim Bowler, Sunday May 7th

Subject: INQUA Matters ... Recent Executive Meeting in Kathmandu

I attach for your information, notes arising from a recent meeting of part of the INQUA Executive arranged to coincide with a PAGES meeting in Kathmandu. Absent were Andre Velitchko, Horst Haagaman, and Steve Porter ... all unable to make it. These notes were forwarded to Steve Porter on my return ... but were written for general consumption by Oz colleagues with an interest in the operations of INQUA.

In preparation for the forthcoming meeting of the National Committee, I should now add that I received last night (May 6th) an urgent fax from Ed Derbyshire ... Ed informs us he met with Allan Chivas on Friday last (May 5th) and now needs to know if the Australian National Committee has made its recommendations for Executive positions ... he goes on to say: "I need to know right away because of the need to circulate National Delegates 3 months before the Congress". Without putting into print my own reactions to this strategy by the Secretary, I shall merely reply that

(a) He should discuss this with the President of the National Committee rather than myself.

(b) To the best of my knowledge, the National Committee will discuss this matter on May 23.

Ed is overlooking the statute that specifies that nominations to Executive position may be received until the first meeting of the General Assembly at Berlin. It puts Allan in a very difficult position ... one which we need sensitively to take on board at our meeting. Some of the reasons and background are outlined in the notes attached. I shall elaborate in more detail when we meet.

The Kathmandu exercise was something of a mixed bag. The PAGES meeting rated about 5 out of 10 ... for the expense involved, I wonder if it was all worthwhile. But such is the way with PAGES and the attempts to set up yet more Science Programs in the hope that someone will fund them. Meanwhile the cost of that exercise with something like $100/day at the top market hotel with plenty available at $30/day around the corner seemed strangely at odds with the economic poverty of surrounding Nepalese.

I attach below for your info, some notes I have written as a result of the INQUA Exec. discussions. I have not tried to cover the agenda, but merely some items of more general interest. One reason for these notes is to keep the National Committee informed.

Reading between the lines, you will discern some disquiet, not only with the handling of Executive nominations but also the conduct of the meeting itself. No papers were circulated beforehand, except a brief agenda list. There was no opportunity to prepare and things were sprung on us at the last moment leaving very little time for considered discussion. Some of this results from the passive role the President plays, leaving virtually everything to others. The Secretary then plays a lone hand ... does a good job in most ways but overplays a bit in others. I hope this can be remedied in the next Executive operations.

Let me know if I can assist in clarifying any residual issues.

Cheers for now.

Nominations for Executive Committee ... at 24th March 1995

Office	Nominee Nominators
President	S.C. Porter (USA) Hungarian N.C.
Secretary	A. Chivas (Aust.) N.Petit-Maire (France) L. Starkel (Poland) Hungarian NC
Treasurer	E.F.J. de Mulder Netherlands NC F. Heller (Switzerland) Hungarian NC
Vice Presidents	A. Velichko Russian NC M. Iriondo Hungarian NC N. Petit-Maire French NC & A. Berger N. Shackleton British NC P.H.J. Richard (Canada) Canadian NC Y. Ota (Japan) Japanese NC
Unspecified Post	Y.A. Park (Korea) Korean NC

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INQUA Executive Meeting Kathmandu April 3 - 8 Reflections by JMB

A meeting of 5 members of the INQUA Executive was held in Kathmandu to coincide with a PAGES meeting on Himalayan-Tibet climatology (April 3-8th). Below I list some of the items from that meeting.

Berlin INQUA ... Report from Prof. Frenzel

- Huge number of paper presentations ... more than 1000.
- Will require 7 consecutive sessions!!
- Excursions ... very expensive ... have been put in the hands of commercial operator who has booked up-market accommodation. (I fear expense is likely to render impossible many of the excursion proposals.)
- Arrangements well in hand for Executive meeting requirements and business meetings.

New Commission Proposals

- Terrestrial Carbon Cycle ... H. Faure
- Commission on Global Atlas ... M. Pecsi

Commission Reviews

- Four Commissions being recommended for closure
  - Applied Quaternary Research
  - Early Man
  - South America
  - Palaeoclimate
- Commissions asked for Project summaries ... most not yet responded. This matter is held until International Congress has had opportunity to approve the Executive's action in regard to restructuring of Commissions. This will obviously be a major item on the Agenda for the IC. Secretary to prepare 1 page summaries of reviews for International Council.

Global Change Committee

- Something of a time bomb ... Future must be decided. Can exist as a Committee for duration of only one Inter-Congress Period. Nat Rutter to structure report, to circulate to Global Change Committee members before Berlin.

Brochure

- Reaffirmed decision at Edmonton to produce for Berlin. Before leaving Kathmandu, Rutter & Bowler to offer amendments to draft circulated by Secretary (Bowler's done next day ... handed to Nat for his contribution on April 9th).

Nominations to Executive Positions

- See list above
- Group Members were asked to submit nominations to the Secretary "not less than 4 months before the Congress" (7.3a). The list of nominations thus received is attached.
- "Additional nomination may be sought by the International Council at its first meeting of the Congress" (7.3b).
- Considerable discussion followed on the nomination for Secretary of Allan Chivas (Australia) by N. Petit-Maire.

In private discussion, Ed Derbyshire had explained to me how Petit-Maire had asked him (Ed) to contact Allan. This he did, and in the process of a long phone call, he explained to Allan "why he should accept nomination" (Ed's words). Nat questioned the propriety of this action, pointing out that if we had individuals running around nominating whomsoever they would, we would have chaos. Reference to the Statutes makes it clear that only nominations from Group Members (Countries) are acceptable (7.3.a). It became clear that the Chivas nomination was not within the Bye-law as it stands. At this stage, Ed turned to me and asked me to sort it out ... a request to which I had some ambivalence in my reply. I pointed out that he (Ed) had got us into this predicament ... he should certainly unravel those threads for which he was responsible.

- On my return, I immediately contacted the Chair of our National Committee. No discussion had been held with Allan ... I therefore contacted Allan Chivas myself to clarify the situation. It was clear that he had been completely misled. Ed had given him to believe that he (Ed) could assure the validity of his nomination, a point quite at variance with the Statutes. Allan had accepted in good faith. Indeed he would make a very good Secretary, but it has to be done within the rubric, and preferably with his National Committee's support (of which he is a member).
- Some of us at Kathmandu expressed a feeling of concern at the role of the current Executive in setting up our successors ... a tricky business ... not entirely without some justification but fraught with dangers ... especially when done incorrectly.

INQUA Agenda

- To be circulated 3 months before Congress ... no matter not on agenda can be given a decision. (5.1.3). National Committees to respond where appropriate.

INQUA Priorities

- Where is INQUA going ?
- What are the current opportunities for the organisation ?
- What kind of leadership (if any) should the Executive be contemplating in this area ?
- These questions, originally raised at Edmonton, were again considered ... it was pointed out that opportunity exists within the President's report to the Berlin Congress to point the way for future possible priorities, bearing in mind the revised strategies asked of Commissions. Executive members were asked to give consideration to INQUA's future priorities ... to communicate these to the President such that he might give them consideration in preparation for his report to the General Assembly at Berlin.

Oz National Committee

- To provide report for Berlin Business meeting.

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CONFERENCE AND MEETING NEWS

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3 - 10 August 1995. **XIV INQUA Congress**, Berlin, Germany. Contact: Partner GmBH, Emma str. 220, 28213 Bremen, Germany. Phone: (49) 421 21 90 73; FAX: (49) 421 21 64 19.

14-18 August 1995. Global **Changes and Geography (International Geographical Union Conference)**, Moscow, Russia. Contact: V.V. Annenkov, IGU Conference, Institute of Geography, Moscow 109017, Russia.

September 1995. **4th European Paleontological and Palynological Congress**, Heerlen, The Netherlands. Contact: Dr G.F.W. Herngreen, Geological Survey of the Netherlands, PO. Box 157 2000AD Haarlem, The Netherlands.

11-15 September 1995. **Workshop on Climatic Change at High Elevation Sites**, Wengen, Switzerland. Contact: Dr Martin Beniston, Dept. Geography, ETH-Zurich, Winterthurerstrasse 190, CH-8057 Zurich, Switzerland. e-mail: beniston@ ezrz1.vmsmail.ethz.ch

24-27 September 1995. **1995 Annual Conference, Institute of Australian Geographers**, Newcastle. Contact: Phillip O'Neill, Department of Geography, The University of Newcastle, Callaghan N.S.W. 2308, Australia. Phone: 049 21 5095 (direct), 049 21 5080 (department); FAX: 049 21 5877; e-mail: GGPMO@cc. newcastle.edu.au

25-29 September 1995. **1st Global Analysis, Interpretation and Modelling (GAIM) Science Conference**, Garmish-Partenkirchen, Germany. Contact: IGBP Secretariat, Institüt für Meterologie, Freie Universitat Berlin, Carl-Heinrich-Becker-Weg 6-10, 12165 Berlin, Germany.

10-14 October 1995. **5th International Conference on Palaeoceanography**, Halifax, Canada. Contact: Trudy D. Lewis, ICP-V, Richmond Terminal, Pier 9, 3295 Barrington St, Halifax, Nova Scotia B3K 5X8, Canada.

31 October - 2 November 1995. **1st Annual GIS Asia/Pacific Conference**, Singapore. Contact: Ms Kathleen Hastings, GIS Asia/Pacific Conference, c/o Pearson Professional Pte. Ltd., 133 Cecil ST #12-01, Keck Seng Tower, Singapore 0106. Phone: 65 323 6373; Fax: 65 323 4725.

27-29 November 1995. **9th (AINSE) Australian Conference on Nuclear Techniques of Analysis & 3rd Vacuum Society of Australia Congress**, Newcastle, NSW, Australia. Contact: Assoc. Prof. D.J. O'Connor, Department of Physics, The University of Newcastle, NSW 2308, Australia. Phone: 049 21 5439; Fax: 049 21 6907; e-mail: phjoc@cc.newcastle.edu.au

22-26 April 1996. **8th International Conference on Luminescence and Electron Spin Resonance Dating**, **(LED 1996)**, Canberra, Australia. Contact: Mrs Judy Papps, Quaternary Dating Research Centre, ANH, RSPAS, Australian National University, Canberra, ACT 0200, Australia. Phone: 61 6 249 4764; Fax: +61 6 249 0315; e-mail: Judy.Papps@anu.edu.au.

22-29 June 1996. **Ninth International Palynological Congress**, Houston, Texas, U.S.A. Contact: D.J. Nichols, U.S. Geological Survey, MS 919, Box 25046, Denver, Colorado 80225-0046, USA. Phone: 303-236-5677; FAX: 303-236-5690; e-mail: dnichols@greenwood.cr. usgs.gov

July 1997. **VIII Pacific Science Inter-Congress**, Suva, Fiji Islands. Contact:

Secretariat, VIII Pacific Science Inter-Congress, c/- School of Pure and Applied Sciences, The University of the South Pacific, PO Box 1168, Suva, Fiji Islands.

28 August - 3 September 1997. **IV International Conference on Geomorphology**, Bologna, Italy. Contact: IV International Conference on Geomorphology, Planning Congressi s.r.l., Via Crociali 2, 1-40138 Bologna (Italia).

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RECENT PUBLICATIONS

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Use the terms "sustainable" and "equitable" wherever possible.

Remember that all climate research, however arcane, is now "policy relevant".

Bear in mind that cost-effectiveness is paramount when dealing with climate change. But don't use the term "incremental costs" as no one knows what it means.

Be sure to point out that dealing with scientific uncertainty is critical in this precautionary phase of the response to global warming.

Don't be afraid to raise spurious scientific controversies. If you don't, the media will.

Stress the interdisciplinary nature of the subject to offset criticism of your lack of experience in the field of climate change.

Ensure that any conclusions you might inadvertently reach will be qualified sufficient to justify further research and, of course, another proposal.

Print your proposal on recycled paper... and recycle the proposal if it fails on first submission.

Source Anon. 1994. *Tiempo*, 13, p. 23

QUATERNARY AUSTRALASIA PAPERS

Paper: Quaternary Australasia 13/1 (1995)

ODP SITE 820 AND THE INITIAL HUMAN COLONISATION OF SAHUL

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Kershaw *et al.'s* (1993) claim that changes in floral composition and charcoal influx that began at ODP site 820 about 140,000 BP were the result of deliberate burning of the vegetation by Aborigines raises several important theoretical issues. First was fire rather than climate the cause of the vegetational changes observed? If so, is it possible to distinguish anthropogenic burning from natural forest fires? Finally, if the burning was anthropogenic, what are the implications of its apparent age for current models of human evolution and the timing of the initial colonisation of Sahul?

Due largely, I suspect, to the controversy inherent in the last point, Kershaw *et al.'s* (1993) claim has been greeted with considerable scepticism by both palynologists and archaeologists (Anderson 1994; Hope 1994; White 1994). These critics noted that the core was sampled extremely coarsely, at approximately 10m or 30,000 year intervals. They also pointed out that the mode of pollen accumulation is problematic, given the core's location in shallow water close to the continental margin. Hence it is unclear whether changes in the pollen source, pollen influx rate, sedimentation source, rate of sediment deposition or post-depositional factors have affected species representation in the pollen spectra. Some of these criticisms will undoubtedly be addressed by the additional samples proposed to take from the top 40m of the core (Kershaw 1994). However, the chief problem for the sceptics appears to be the presumption that the observed vegetational changes were the result of human activity and the time at which they occurred, about 140,000 BP. If Kershaw's interpretation is correct, its implications for Sahulian prehistory are profound.

Humans are not endemic to Sahul. They can only have reached the landmass by over-water dispersal from Sunda-land. Moreover, they are the only large non-volant mammal to have done so unaided (Jones 1989, 1992). This fact is thought to illustrate their adaptive abilities (Davidson & Noble 1992). While the journey would undoubtedly have been least hazardous when sea levels were at their lowest during the glacial maxima, even then the coast of Sahul would still not have been visible from Timor or the Moluccas. Thus, whether human colonisation was purposive (Gamble 1993) or accidental remains moot. That people reached Australia in sufficient numbers to form a viable population is clear from the continent-wide distribution of the earliest artefact assemblages, but their age is debatable. Although the temporal limitations of 14C are well known (Aitken, 1990), it is the only chronometric technique to have been applied at most archaeological sites in Australia. Hence, the oldest known artefacts all date to <40,000 BP. This "date" has become enshrined in the archaeological literature (Allen 1989; Bowdler 1990), although it is probably an artefact of the 14C technique. Recently, coherent series of luminescence dates have been obtained from Malakunanja II and Nauwalabila I that throw doubt on this short chronology (Roberts *et al*. 1990, 1994a, 1994b). The lowest artefact-bearing strata in both sites date to 60,000-50,000 BP, suggesting that the inundation of Sunda-land by rising sea levels about 65,000 BP (Chappel 1993) might have persuaded people to migrate (Thiel 1987). Although White (1994) accepts these luminescence ages, Bowdler (1992, 1993) and Allen (1994) do not. They maintain that the 14C dates represent "true ages" in "real time".

Argument over these conflicting chronologies is somewhat academic because both fit comfortably within current models of human evolution (Kramer 1991; Bräuer & Smith 1992). Regardless of whether anatomically modern humans (AMH) originated solely in Africa or developed independently in many parts of the world, they are unknown

before oxygen isotope stage 6. Therefore, if the initial human colonisation of Sahul occurred about 140,000 BP, as Kershaw (1994a) suggested, the immigrants are unlikely to have been AMH. However, no evidence for pre-modern hominids has yet been found in Australia (Brown 1993). Moreover, the colonising abilities of such species are unclear. Although *Homo erectus* apparently reached Sunda-land quite early (Swisher *et al*. 1994), they would not have had to cross any water barriers to get there. On the other hand, the spread of archaic *Homo sapiens* into the heartland of Europe, which also probably took place entirely overland, appears to have been considerably delayed (Roebrooks & von Kolfschoten 1994), possibly by the ubiquitous mountain barriers and often inhospitable climate. It is hardly surprising, therefore, that the suggestion that pre-modern hominids voyaged to Australia about 140,000 BP has been greeted with scepticism (Hope 1994). Particularly since the only evidence advanced in its support is changes in the pollen spectra from ODP site 820 and Lake George (Singh & Geissler 1985). That does not mean that colonisation could not have occurred at that time, merely that better evidence, for example indubitable artefacts from contexts which can be shown independently to be of equal antiquity, will be required before most anthropologists would accept that it had (Anderson 1994). No such artefacts have yet been recovered from radiometrically-dated contexts anywhere in Sahul. Of course, they may exist, but the earliest known Sahulian artefacts are so typologically amorphous that unless material is recovered from radiometrically dated contexts, its age cannot be determined.

Thus, the hypothesis that humans might have entered Australia about 140,000 BP remains problematic. It requires that pre-modern hominids were able to colonise over water, an ability that they showed nowhere else, and no supporting evidence in the form of artefacts of equal antiquity has yet been found anywhere in Sahul. Moreover, it rests solely on palynological data interpreted as evidence that once in Australia people began to burn the vegetation, causing a shift from fire sensitive rainforest to fire tolerant sclerophyll woodland. This is the crux of the problem.

Both Singh & Geissler (1985) and Kershaw *et al*. (1993; Kershaw 1994) *assumed* that anthropogenic activity was the cause of the vegetational changes their sites recorded. However, that cause must be demonstrated or their arguments are simply tautologous. It *may* be legitimate to suggest, after excluding other possible causes, that human activity caused environmental changes observed at times when it can be shown independently that people were present in the area affected. The classic example of this phenomenon is the decline about 5,000 BP of *Ulmus* spp. in northwestern Europe (Aaby 1986; Scaife 1987), although the evidence on which that scenario is based is open to question (see below). However it is *not* legitimate to use environmental changes, which could have been the result of a variety of non-anthropogenic factors, to "prove" that humans were present in an area and at a time for which no other anthropogenic evidence is available, unless all other possible agents of change have been convincingly excluded. This has yet to be done at either ODP site 820 or Lake George.

Thus the fundamental questions raised by these pollen spectra are: whether the observed vegetation shifts were caused by fire rather than climatic changes and whether the fires were lit by people rather than started naturally. In order to address those questions the palynological data will first be briefly reviewed. The much younger pollen record from Lynch's Crater is also relevant here (Kershaw 1976).

Charcoal particles enter the pollen record in great numbers at Lynch's Crater for the first time < 40,000 BP, simultaneously with a marked shift from rainforest to sclerophyll taxa. During the previous 150,000 or so years, charcoal is comparatively rare and the fluctuations in arboreal taxa accord quite well with known changes in global climate. Hence, this core records a sequence of probably climatically induced vegetational shifts to which another factor is added <40,000 BP, that brings large quantities of charcoal into the record. The pollen record from Lake George spans the Brunhes epoch. Numerous charcoal peaks are visible in this core (Williams *et al. 1993*: 191). The first occurred during oxygen isotope stages 15 and 13, the latter being accompanied by an increase in sclerophyll taxa, but no decline in rainforest taxa. Subsequently, little charcoal is recorded until, beginning in stage 7 and continuing to the top of the core, a series of

increasingly large peaks is accompanied by variations in sclerophyll taxa and diminishing numbers of rainforest taxa. The marked increase <40,000 BP in sclerophyll taxa at Lynch's Crater is not apparent at Lake George, although stages 9 and 7 are well marked at the latter site. The data from ODP site 820 are the most difficult to interpret. The charcoal peak at >1,000,000 BP is not paralleled by marked changes in the arboreal taxa, nor was it explained by Kershaw *et al*. (1993). Only the peak identified at -26m is accompanied by a change from rainforest to sclerophyll taxa.

Thus, these cores appear to record asynchronous site-specific vegetational changes. This suggests that a unitary explanation, whether climatic or anthropogenic, is not appropriate. Instead each site must be interpreted individually. A strong argument can be made that the vegetational changes recorded <40,000 BP at Lynch's Crater *could* be due to human activity (Kershaw 1994; White 1994). Not only did they occur after humans are known to have reached Australia, but they are unlike the earlier changes which occurred at this site, for which a climatic interpretation seems more likely. Thus, these data meet Anderson's (1994) criteria for identifying human activity. The data from Lake George and ODP site 820 are more problematic. Interpretation of the latter site must await the detailed analyses that Kershaw (1994a) proposes to undertake, although it is noteworthy that Kershaw *et al*. (1993, 1994) did not attribute the charcoal peak at >1,000,000 BP to human activity. That leaves Lake George: Singh & Geissler (1985) never suggested that the charcoal peaks in stages 15 and 13 were anthropogenically caused. They only attributed the peaks in Zone F (stage 5e) and above to human activity. White (1994) also accepts that human activity was the main agent of change in Zone F, but only if it can be redated to about 60,000 BP. These arguments contain an element of special pleading. Either charcoal peaks are the result of Aborigines' pyromaniac propensities, in which case their time of occurrence has to be accepted, or they are not in which case the age of these events is immaterial.

Like Hope (1994) and Anderson (1994), I question whether Aboriginal burning was *necessarily* the cause of the vegetational changes observed at these sites. Particularly since the older data from Lake George and ODP site 820 have *never* been attributed to human activity. Other factors such as climatic change or natural fires also need to be considered. It is true that climate in Australia oscillated less during the Quaternary than it did in northern temperate latitudes and that its fluctuations are not known in detail, which makes the elucidation of its environmental effects difficult. It is also true that the pollen and charcoal records in these cores do not co-vary, suggesting that the environments they represent were responding to local conditions. Nonetheless, Kershaw (Williams *et al*. 1993) was able to correlate the pollen records from Lynch's Crater and Lake George with the marine isotope record, suggesting that the vegetational changes recorded at those sites included a climatic signal. The possibility that the charcoal peaks at ODP site 820 had a similar cause needs to be considered before alternative explanatory hypotheses are proposed.

The "burning question" (Horton 1982) is more difficult to resolve, because there does not seem to be any way of distinguishing natural from humanly-set fires, from the pollen record alone. Fire was already a feature of the Australian environment in the Tertiary (Kemp 1981). Hence, it is not surprising that most of the endemic flora was well-adapted to regular burning long before human arrival (Gill 1975; Gill *et al.* 1981). Therefore, the influence of fires whether anthropogenic or natural, on the vegetation should not be over-emphasised. It is generally accepted that Aboriginal fire regimes was intended to influence the biomass by controlling the availability of browse (Jones 1969; Gould 1971; Hallam 1975). Furthermore, it is assumed that in burning off leaf litter and other dead vegetation Aboriginal fires might occasionally got out of hand. However, the extent and efficacy of such burning should not be exaggerated (Horton 1982). For example, it would seem that mulga country was not burnt (Gardner 1957; Ford 1985). Moreover, I would suggest that such manipulative strategies were not instituted until long after Australia was first settled. Rindos & Webb (1992) argued that human migrants into previously unexplored areas would have been unlikely to exploit new territory as efficiently as its subsequent occupants who had time to learn the full range of resources it contained. Hence we suggested that colonising populations would have been comparatively thinly spread and would have left only sparse archaeological traces. If so, they would not

immediately begin to burn the vegetation. Only after they had "settled down" and their numbers had begun to approach "saturation" for the environments in which they lived, would people have begun to manipulate them by burning off to encourage new growth. Head (1994) advanced a similar argument. This model helps to explain the fact that, world-wide, palynological evidence for humanly-caused vegetational changes post-dates initial settlement by several millennia (Anderson 1994). For example, in extreme South America charcoal particles appear suddenly in a series of pollen diagram about 10,000 BP (C. Heusser pers. comm.). Charcoal continues to be variably present until about 5,000 BP, when it disappears. Heusser considers that this charcoal is anthropogenic and that humans affected the environment of this region differently after the introduction of agriculture, so that charcoal no longer entered the pollen record <5,000 BP. This scenario is congruent with what is known of the prehistory of the region. Humans reached Tierra del Fuego by about 11,000 BP (Fiedel 1992). They may have been at Monte Verde in southern Chile rather earlier, about 13,000 BP (Dillehay 1988). Hence, Heusser's data would suggest that in extreme South America people began to make their presence felt palynologically within millennia of their arrival. On the other hand, despite the fact that people are definitely known to have colonised North America by 12,000 BP (Meltzer, 1993), when discussing the charcoal record in pollen diagrams from Ontario and Washington state, Cwynar (1978, 1987) did not hesitate to attribute its presence to the climatic changes that were undoubtedly occurring at that time, rather than to human activity. The differences in these interpretative paradigms are due perhaps to the fact that, unlike the Aborigines, Palaeoindians are not known to have deliberately burned their environment, whereas it is known to have changed as the climate of the present interglacial was established. In other words, in North and South America those explanations of charcoal abundance have been chosen that best fit the other data available.

The importance of considering all the available evidence is best illustrated by the changing hypotheses proposed to explain the decline at about 5,000 BP of elm (*Ulmus* spp.) in Western Europe (Aaby 1986; Scaife 1987). This decline was initially attributed to the climatic changes taking place at the time, although other tree species did not appear to be affected. Subsequent research suggested that its cause was anthropogenic: forest clearance connected with the introduction of agriculture affected elm more than other trees. However, clearance and agriculture are not necessarily interlinked. Then *Scolytus scolytus* was identified, suggesting that disease might have contributed to the elm decline, although again effect does not necessarily follow cause. Detailed analysis of closely sampled polliniferous sediments now suggests that the temporal pattern of elm decline was much more subtle and complicated than previously thought. It now appears that the period of decline lasted for centuries. In some places it preceded the introduction of cereals or evidence for *S. scolytus*. In some places elm regenerated, only to decline again. Thus, the elm decline was clearly a complex and drawn-out process which appears to have had several causes.

Similarly detailed work needs to be carried out on the Australian pollen record before it will be possible to determine whether climate, human activity or natural fires, or a combination of all three, were chiefly responsible for the vegetational changes observed at ODP site 820, Lake George and Lynch's Crater. Until such work is undertaken, the vegetational changes recorded at these sites should not be attributed to human activity in the absence of supporting artefactual evidence.

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QUATERNARY AUSTRALASIA PAPERS

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UTILISATION OF HISTORICAL RECORDS IN MAPPING AND EXPLAINING THE BURIAL OF SOILS TO THE NORTH OF BENDIGO, VICTORIA

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Abstract

Field-work carried out to test the implications of evidence contained in the Report of a Royal Commission published in 1859, has identified an area of over 700 km^2 to the north of Bendigo which has been affected by the inundation of semi-fluid mining waste (sludge) from the puddling phase of gold-mining on the Bendigo gold fields.

Introduction

This study is the continuation of work discussed in an earlier publication (Cole 1994). In that work the scope for landscape reconstruction by means of registering archival and modern maps in a digital spatial data base (a Geographical Information System) was demonstrated with regard to an 1859 map of the location of contemporary mining waste which had buried soils in the valley of Bendigo Creek. The map was part of the Report of the Royal Commission appointed to "Enquire into the Best Method of Removing the Sludge from the Gold Fields" (Victoria 1859-60) and referred to the gold fields in the Bendigo area around the township of Sandhurst (now known as Bendigo). "Sludge" was the name given to the semi-fluid mixture (slurry) of rock debris, soil and water, the waste-product of washing or "puddling" the alluvium and regolith to remove the gold. The current study considers information contained in the Report regarding the inundation, by the sludge run-off, of agricultural and pastoral lands many miles downstream from Bendigo.

Background

The bedrock of the hills in the Bendigo area is of lower Ordovician origin, and is composed of a sequence of sandstone, siltstone and mudstone approximately 3,000 m thick, which was subsequently compacted, uplifted and folded. Further folding during the Devonian was accompanied by granitic intrusion, and gold-bearing quartz was injected as hot solutions replacing the rock, particularly along lines of weakness at the crests and troughs of the folds (Wilkinson 1978). Exposure of these rocks since the late Palaeozoic has produced a mature landscape. Subsequent erosion of the rocks containing the quartz reefs has liberated the gold and concentrated it in the alluvium of the gullies and streams, along with sequences of clay, sand, and rock debris (Stillwell 1919: 11; Willman & Wilkinson 1993). The presence of ferruginous pisolites in the sludge indicates that the puddlers worked regolith between and above the gullies, and that gold had migrated into the regolith and precipitated there (electrum grains and nuggets) during earlier phases of weathering and landscape evolution.

Gold was discovered in the Bendigo area in 1851 (Lerk 1991: 11-12). The earliest gold recovered was won by washing or puddling it out of the extensive alluvial deposits and *in situ* regolith. For the first year or two the miners usually only washed the sands and gravels from below the (generally scanty) topsoil and above the first layer of clay ("first bottoming", or "shallow sinking") (Anderson 1978: 65). This reluctance to mine the clay was understandable because when damp it was very sticky. When dry, however, it was frequently referred to as "cement", and was very difficult to break-up, often needing a sledge-hammer or even explosives (Brough Smyth 1869: 207-208; *The Argus* 13/11/1857: 6).

By 1853 it was widely accepted that the clay "first bottom" was generally auriferous, and often the underlying layers were too, so the practice of "deep sinking" was adopted, in which everything down to bedrock was mined. This, together with the practice of "second bottoming", in which only the clay layer immediately above the bedrock was washed, quickly became the predominant method of alluvial mining (*The Argus* 4/10/1853: 7; Anderson 1978: 9). The introduction of puddling machines, or mills, greatly increased the amount of material which could be worked at one time. A puddling machine (Figure 1) was a large, lined circular pit (often 5-6 meters diameter) surrounding a central pillar which supported a cross-beam from the ends of which hung two harrows. The beam was pulled by a horse walking around the outside of the pit. The material to be puddled was placed into the pit, which received a constant flow of water from an inlet channel. As the horse walked around the pit, the harrows churned the mixture into a mud. Eventually the heavier particles (gravels, quartz chips, gold) settled to the bottom, and these were later removed for cradling when everything but the gold was washed away. The lighter particles such as clays and sands stayed in suspension, to be flushed away as "sludge" down an outlet channel. Most of the quartz chips, gravels and sands settled out of the discharge fairly quickly, choking the stream-beds, but the clay tended to remain in suspension and travelled for many miles.

It was estimated by the Commission that as much as 2 dwt. (3.54 grams) of fine gold were being flushed away with every ton (1.016 tonnes) of sludge, and it was acknowledged that "... there is at present no machinery upon this gold field by means of which this auriferous silt could be worked or amalgamated so as to yield remunerative results ..." (Victoria 1859-60: 16). Loss of gold has been confirmed by the presence of very fine gold grains in specimens taken of the hard-setting sludge layer mapped during the field-work reported here (see below).

Quantity of mining waste produced

By 1855 there were an estimated 2000 puddling machines in the Bendigo district (Anderson 1978: 78). By late 1858 the accumulated problems caused by the continuing discharge were such that a Royal Commission was established in November 1858 to enquire into the situation. The Report of that Commission was submitted to Parliament in early February 1859. It detailed not only the extent and the gravity of the problem within Sandhurst itself, but also something of the problems being experienced for quite some distance downstream.

At that time there was no separate channel into which the sludge could be drained, and no area or "reservoir" set aside to receive the sludge. Miners were permitted to run their discharge into some of the creeks, and the storm-water channel, with the result that the natural drainage system for the area became choked, and in many places obliterated, and the storm-water channel itself became choked and rendered useless. The two-fold result was that storms often led to serious flooding by both water and mud (with occasional loss of life) within Sandhurst, and downstream the sludge overflowed the shallow creek banks and spread out onto the land.

It was estimated by the Royal Commission that approximately 3,000,000 yds^3 (2,293,000 m^3) of material were puddled annually by puddling machines whose waste drained into Bendigo Creek and its tributary gullies. Of this, it was estimated that approximately one quarter consisted of the heavier, coarse-grained material, and the remainder, approximately 2,250,000 yds^3 (1,720,350 m^3), was the fine-grained material which formed the sludge (Victoria 1859-60: 20). On these figures it can be assumed that during the previous five years over 11,000,000 yds^3 (over 8,600,000 m^3) of sludge and 3,750,000 yds^3 (over 2,800,000 m^3) of gravels and sands had been discharged into and around Bendigo Creek. This is enough to cover an area of over 200 km^3 to a depth of 5 cm.

Figure 1: Plan and section of a puddling machine (source: Brough Smyth 1869: 618).

The number of puddling machines operating in the area did not decrease significantly until the mid-late 1860s (Brough Smyth 1869: 93; Lerk 1991: 15). If the above annual estimate of material discharged is taken to apply to the amount discharged over ten years (1854-1864), then the amount discharged would have been sufficient to cover an area of over 400 km^2 to a depth of 5 cm.

Where did the mining waste go?

The Report of the Royal Commission noted that in early January 1859 the Commissioners had undertaken a tour of "... inspection of the country bordering upon the course of the Bendigo Creek, to a distance of about fifty miles from Sandhurst ..." (Victoria 1859-60: 66), which enabled them to report upon "... the incalculable mischief which the sludge has inflicted upon the sold lands, the watercourses, and the pastures between Sandhurst and the Murray ..." (Victoria 1859-60: 10)[1]. It was noted that "... even on the plains, thirty or forty miles away from Sandhurst, where the sludge flows thin, and is relieved from its heavier particles, *we found it baked into a perfect concrete,* and in thicknesses varying up to two feet or more ..." (Victoria 1859-60: 13)[2]. "In fact ..." the Report also noted, "... the entire course of the sludge through these plains is marked by filled up watercourses and flooded pasture lands ..." (Victoria 1859-60: 5).

The Commission had no doubt whatsoever that the sludge had travelled a considerable distance downstream from Sandhurst, and that it was causing extensive and serious damage to the agricultural and pastoral lands to the north of the gold fields. It was unlikely that the physical evidence for such widespread inundation has completely disappeared over the intervening one hundred and thirty years, so the challenge for this study was to locate the evidence of that inundation in the current landscape, and to estimate its extent.

Four hundred and sixty three field-sites were checked for the presence of a hard-setting, "concrete" layer with a buried soil beneath. Nearly all of the sites were at road-side dams, in holes excavated to a depth of several meters. Most of these dams were positioned to capture run-off from the nearby road, and were linked to road-side drainage by a channel. Dry conditions experienced over the times at which field-work was undertaken (April and July 1994, February 1995) meant that the water level in these dams was generally low, in most cases exposing 2-3 metres of dam face. Figure 2[3] shows the location of the sites at which an unstructured, hard-setting clay horizon of at least 1 cm thickness was found overlying a well-developed, well-structured, pedal horizon . Many of these sites lie beyond the line marking a distance of 30 miles (48 km) north of Sandhurst (Bendigo).

Suggested origins of the located sludge

It is possible that at least some of the sludge found in the study area did not come from the mining areas of Sandhurst which drained into Bendigo Creek, that is from the eastern side of the Bendigo gold field. On the western sector of the gold field many of the gullies drained towards and into Myers Creek which flowed north on a relatively straight course to Kow Swamp, being joined by Piccaninny Creek, and joining Mount Hope Creek on the way. It was noted in the Royal Commission Report that an estimated five hundred puddling machines were in this area, being approximately one-third of the number reported to be in operation on the eastern side of the gold field. The sludge discharged from these machines would have been approximately 2,867m daily, or 573,450m annually (Victoria 1859-60: 14, 20). Figure 2 also shows the possible origins of the sludge located in the study area for this project.

Field-work results

Sludge deposits (thickness varied from a few centimetres to three metres) were identified across a wide area, the generalised outer boundary for which encloses over 700 km^2 (Figure 2). The plot also shows a suggested outline for the farmland inundated by sludge coming from the diggings draining into Bendigo Creek, an estimated area of 455 km^2.

Figure 2: Distribution, area and origin of sludge layer.

It has been suggested that the hard-setting clay layer found over so much of the study area is either "calcareous dust" (Mikhail 1976), or the result of compaction (Land Conservation Council, Victoria 1978: 87; Lorimer & Schoknecht 1987, 153), but it is argued here that the layer is in fact allogenic, the result of evaporation of the water content from the sludge discharged from the puddling machines of the Bendigo gold fields. This allogenic origin is confirmed by the presence of pisolites, rough, angular quartz chips and gold within the hard-setting layer.

Plot 2A (Figure 3) shows the distribution of the 442 sites (95% of total sites) at which pisolites were found, either as surface lag on the walls of the farm dam, and/or within the hard-setting (sludge) layer. Plot 2B (Figure 3) shows the distribution of the 32 sites (7% of total sites) at which rough, angular quartz chips were found, either as surface lag, and/or within the hard-setting clay layer. The fact that these chips were rough and not rounded is consistent with the proposition that they were not river-bed material, but actually mining debris which had travelled a short distance.

Preliminary assay work on samples of the hard-setting layer has been undertaken, with the following results: 18 sites sampled: at 17 sites gold occurs at >4.4 grams/tonne in the hard-setting layer; at 1 site (the most northerly site tested, *c*. 60 km NW of Bendigo) 12.1 grams/tonne is recorded in pisolite samples.

The above amounts of gold recorded in the hard-setting layer are in excess of that estimated by the Royal Commission as being lost with the sludge (see above), but two factors must be considered here. First, that much of the gold reported as being flushed away with the sludge was of a grain size visible to the naked eye, and second, retrieval and assay methods were crude by comparison with those available today (Victoria 1859-60: 23, 28). For this study the acid digestion technique was used[4]. Further testing is currently being undertaken on samples from certain sites to ascertain the difference between the amount of gold recorded in the hard-setting surface layer, and that in the buried peds underneath.

The presence of very fine gold (not visible in the samples) and ferruginous pisolites in the hard-setting layer/sludge capping indicates that much of the gold mined or lost in the sludge was secondary (supergene) precipitate in the form of "lectrum grains" precipitated from low-temperature, moderately saline, oxygen-saturated fluids (Jaireth 1994).

Plate 1 depicts the unnaturally flat landscape typical of the area in which a sludge capping is identified. The site is north of Bendigo Creek/Piccaninny Creek (marked by the line of trees), and the exposure also typifies the marked difference in structure between the hard-setting sludge capping and the underlying pedal horizon. The capping at this location was approximately 18 cm thick, and contained pisolites. The unnaturally flat landscape is to be expected in an area where a semi-fluid layer has flooded the topography, and remained. Many of the sites shows an undulating lower edge of the sludge capping, consistent with the proposition that sludge flooded over and filled slight topographical depressions. The area had not been uniformly covered, but had occasional "inliers" which had obviously escaped inundation by being slightly higher than the surrounding areas. The variations in the depth of the sludge capping between the sites (often 20-30 cm over 20 meter distance) indicates that the pre-inundation landscape was gently undulating. The effect on the natural drainage of the inundated area is currently being investigated, and is the subject of a paper in preparation.

Conclusion

Statements made by the Sludge Royal Commission of 1858-59 with regard to the nature of the sludge, and the extent of its spread downstream, have been verified in the field. This demonstrates the use which can, and should, be made of historical records when seeking an explanation for the nature and distribution of soils and regolith materials in areas downstream from nineteenth century alluvial gold fields.

Figure 3: Distribution of pisolites (A) and quartz chips (B).

Plate 1: Site 53 demonstrating (a) the unnaturally flat landscape typical of the area in which a sludge capping was identified, and (b) the marked difference in structure between the hard-setting sludge capping and the underlying pedal layer (L.F. Peterson, April 1994).

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Footnotes

1. The "sold lands" referred to were in Epsom and Huntly, 8 and 12 km down-stream from Sandhurst respectively. The unsuccessful claims for compensation by many of the owners is the subject of a paper in preparation.
2. The italics are in the original document.
3. It should be noted that the plots in this paper are not maps as such, but are representations of the digital information contained in the author's computer data-base. The G.I.S. package used for this study was ARC/INFO 6.1. and the data-base established for this study includes all data respecting the field-sites (463 sites), digital versions of relevant current topographical maps (purchased from Survey and Mapping, Victoria), and digital versions of various historical maps (generated by the author).
4. This technique involves the dissolution of gold from a finely divided sample, in hot *aqua regia* and HCl, and the quantitative analysis of the dissolution product using an Atomic Absorption Spectrophotometer.

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COVER ILLUSTRATION

The front cover illustrates part of the stratigraphic table depicting the later stages of the evolution of palaeosols in laterite and silcrete profiles in Australia, as illustrated recently by Jon Firman. Firman summarises his overview of Australian palaeosols by commenting that laterite and silcrete profiles are common in the arid and semi-arid areas of the Australian Precambrian Shield. Much of the geological history of the shield subsequent to its early development is recorded in ancient cover rocks and younger basin sediments which occur in important stratigraphic sequences, particularly on the margins of the shield. Within these sequences, weathering zones and palaeosols were developed which individually and as assemblages of layers and horizons record the history of weathering and of soil formation since the Proterozoic. Laterite and silcrete profiles are seen to be response to changes in groundwater conditions at particular times in the past. The palaeosols record the evolution of the regolith. Older weathering zones and bleached rocks were features of successive landscapes after the early Palaeozoic, ferruginous mottling, ferricrete and silcrete pans were formed after the early Cainozoic, and ferricretes and mottled clay palaeosols (some of which have been described as "laterite") were formed during and after the Pliocene. Materials in laterite and silcrete profiles are overlain in places by calcretes formed after the early Pleistocene and by younger soils. The assemblages are distinctive and are characteristic of particular morpholithological provinces. The front cover illustration is adapted from Figure 9 in Firman, J.B. 1994. Paleosols in laterite and silcrete profiles: Evidence from the South East Margin of the Australian Precambrian Shield. *Earth Science Reviews*, 36, 149-179.