EIGHTH BIENNIAL CONFERENCE OF THE

AUSTRALIAN AND NEW ZEALAND GEOMORPHOLOGY GROUP

ABSTRACT BOOKLET

GOOLWA, SOUTH AUSTRALIA

NOVEMBER 15th - 20th

1998

EIGHTH BIENNIAL CONFERENCE OF THE AUSTRALIAN AND NEW ZEALAND GEOMORPHOLOGY GROUP

November 15th - 20th, 1998
Goolwa, South Australia

Welcome to the eighth conference of the Australian and New Zealand Geomorphology Group at Goolwa in Southern Far Australia. We have kept to one of the few 'rules' of the group and that is that the conference should not be held in a major population centre, but in a small rural setting. This has some disadvantages from an organisational point of view but we hope that the advantages, especially the geomorphology of Fleurieu Peninsula, far outweigh them.

There are some 64 oral papers and 10 posters. There is a wide range of topics being presented, a healthy sign, but sometimes a nightmare for organising rational groupings. Speakers should adhere closely to their allotted times of 20 minutes for presentation and 5 minutes for questions. A slide preparation area is available on the stage. Posters should be on display throughout the period of the conference and presenters should be by their posters on Wednesday lunch time to parry questions. There will be a Special Interest discussion on palaeochannels following afternoon tea on Wednesday.

The abstracts are presented in alphabetical order but page numbers after the title of the talk in the programme of speakers will direct you to the appropriate abstract.

When Joe Jennings was once asked whether he thought that Geomorphology was an art or a science, he replied that personally he preferred to regard it as a sport! Enjoy.

8th Australian and New Zealand, Geomorphology Group Conference Goolwa, South Australia, 15th - 20th November, 1998

CONFERENCE PROGRAMME

SUNDAY 15TH NOVEMBER - REGISTRATION 4 pm to 7 pm
Registration will be in the Centenary Hall, with access via the rear entrance from 4 pm on Sunday 15th Nov. Late arrivals may register on Monday morning.

MONDAY 16th November - 8.00 am REGISTRATION
Page numbers following title of talk refer to pages in the Book of Abstracts.

Session Coordinator: Martin Williams

9.00 Introduction - *Bob Bourman*

Keynote Speaker

9.15 *Vic Gostin* - Geological Background to South Australian Scenery (p 24)

9.50 *Maria Coleman* - SEM analysis of quartz sand grains as a method of distinguishing between alluvial and aeolian sediments from the northeast desert region of South Australia (p 13)

10.15 *Fletcher Townsend and Paul Hesse* - Aeolian additions to the soils of Southeastern Australia (p 56)

10.40 *Mark Bishop* - A systems analysis of the morphologic evolution of the Gurra Gurra crescentic dunes, Strzelecki Desert, South Australia (p 3)

MORNING TEA 11.05 - 11.20

Fluvial
Session Co-ordinator: Chris Gippel

11.20 *Ian Rutherfurd* - Taming slugs: Understanding and managing anthropogenic sand in a large catchment (p 49)

11.45 *Tony Broderick and David Outhet* - The geomorphic response of receiving streams for inter-basin water transfer on the north coast of NSW (p 6)

12.10 *Tim Cohen and Gary Brierley* - Channel instability in a forested catchment: A case study from Jones Creek, East Gippsland, Australia (p 12)

12.35 *David Dunkerley* - The effects of plant litter on sediment detachment and transport in the arid zone: Rainfall simulation experiments at Fowlers Gap, NSW (p 18)

LUNCH AND LAUNCH OF QUATERNARY ENVIRONMENTS 1.00 - 1.50

Fluvial
Session Co-ordinator: Ian Prosser

1.50 *Kirsty Fryirs and Gary Brierley* - Slope-channel decoupling in Wolumla catchment, NSW, Australia: The changing nature of sediment sources following European settlement (p 22)

2.15 *Chris Gippel and Juliet Bird* - Application of stream power analysis to management of an incised stream channel (p 23)

2.40 *Kathryn Jerie and Ian Rutherfurd* - Resurrecting the dead: Can fluvial geomorphology work miracles in rehabilitating Australian streams? (p 31)

3.05 *Justine Kemp* - Morphology of a very quiet river, the Lachlan downstream of Cowra, NSW (p 34)

MONDAY 16th November (Cont)

AFTERNOON TEA 3.30 -3.50

Mainly dating
Session Co-ordinator: John Prescott

3.50 *Olav Lian, Peter Almond, Rodger Sparks and Neville Moar* - Optical dating of loess and silt from Okitaro Forest, West Coast of South Island, New Zealand (p 37)

4.15 *David Price* - Thermoluminescence dating in Australia: From Lake Mungo to Jinmium and back (p 45)

4.40 *Brad Pillans and Bob Bourman* - Mid Pleistocene arid shift in Southern Australia and New Zealand, dated by magnetostratigraphy (p 44)

5.05 *Allan Chivas* - Chemical geomorphology: What came down in the last shower (or the airborne return of marine solutes to the continents) (p 10)

5.30 *John Chappell* - Relationships between hillslope form, soil production and transport (p 11)

TUESDAY **17th November**

Coastal

Session Coordinator: Colin Murray-Wallace

9.00 *Rebecca Bartley and Peter Cowell* - Barrier translation for different rates of sea level rise (p 2)

9.25 *Robert Brander* - Sediment transport in low energy rip current systems (p 5)

9.50 *Ric Daniel, Chris von der Borch, Herb Veeh, Noel James and Yvonne Bone* - Late Quaternary evolution of Streaky Bay, South Australia: Relative sea levels and timing (p 15)

10.15 *Jeffrey Doucette, Ian Eliot, Gerhard Masselink and Charitha Pattiaratchi* - The distribution of nearshore bed morphologies on sheltered, sandy beaches in southwestern Australia (p 16)

10.40 *David Kennedy and Colin Woodroffe* - Holocene lagoonal infill at the latitudinal limits of reef growth, Lord Howe Island, Tasman Sea (p 35)

MORNING TEA 11.05-11.25

Coastal

Session Coordinator: Nick Harvey

11.25 *Errol McLean and J.B. Hinwood* - The Mother's Day of all storms: Effects on the NSW South Coast estuaries (p 39)

11.50 *Gerhard Masselink* - Beach cusp morphology and swash circulation (p 40)

12.15 *Colin Murray-Wallace, Alan Beu, George Kendrick, Len Brown, Tony Belperio and John Sherwood* Geomorphological implications of the occurrence of the arcoid bivalve *Anadara trapezia* (Deshayes, 1839) in the Australian Later Quaternary (p 41)

12.40 *John Webb, Jim Specht and Bill Boyd* - Holocene eustatic and tectonic effects on the geomorphology of the southern New Britain coast, Papua, New Guinea (p 60)

LUNCH and GENERAL BUSINESS MEETING 1.05 - 2.15

Session Coordinator: Liz Campbell

2.15 *David Wheeler, Bob Young and Ted Bryant* - Tsunami deposits near Steamers Beach, Jervis Bay, NSW, Australia. (p 61)

2.40 *Esmée Webb* - The influence of geomorphology on the location of Aboriginal sites in central Western Australia (p 59)

3.05 *Trish Fanning, Simon Holdaway and Dan Witter* - Landscape and living place: Associations between landform features and Aboriginal camp sites in far western NSW during the Late Holocene (p 20)

AFTERNOON TEA 3.30 - 3.50

Fluvial

Session Coordinator: David Dunkerley

3.50 *Kate Brown* - Examining the influence of landscape features on hillslope sediment transport in an arid environment (p 7)

4.15 *Ken Page, Paul Frazier and Kim Rothe* - Floodplain formation by oblique accretion (p 43)

4.30 *Ian Prosser, Trevor Dowling and Paul Rustomji* - Systematic changes to hillslope morphology with stream order and their implications for sediment delivery to streams (p 46)

4.55 *Lisa Worrall* - Evolution of the drainage net in the Balgarri area, northwest of Kalgoorlie in the Eastern Goldfields region of Western Australia (p 64)

WEDNESDAY 18th November

Landscape evolution

Session Coordinator: Colin Pain

9.00 *Steve Hill, G. Shirtliff, M.Holzapfel, Kylie Foster, Dave Gibson, J. Wilford, Ian Roach, Lea Moore and Tony Eggleton* - Regolith geology and landscape evolution of the southern Broken Hill Block, western NSW (p 29)

9.25 *Kerrie Tomkins and Paul Hesse* - Post Mid-Miocene episodes of uplift of intraplate highlands: The Macquarie River valley, Australia (p 54)

9.50 *Max Brown* - The "Palaeo-Towamba" - A SE-flowing Palaeocene river draining the Monaro District, SE NSW (p 8)

10.15 *Paul O'Sullivan, Barry Kohn, Brad Pillans and Colin Pain* - Late Palaeozoic to Cainozoic landscape evolution of the North Parkes Mine area, NSW:Constraints from fission track and Palaeomagnetic data (p 42)

MORNING TEA 10.40 - 11.00

WEDNESDAY 18th November (Cont)

Landscape evolution
Session Coordinator: Cliff Ollier

11.00 **Plenary Speech:** *Martin Williams* - From the Nile Basin to the Flinders Ranges: Catchment response to environmental change (p 63)

11.40 *Michelle Tait and John Webb* - Silcrete formation in the Mount Wood Hills area, NW NSW (p 53)

12.05 *Steve Hill and Bob Bourman* - Mosaics of Ongoing Development in the Evolution of Landscapes (MODEL): A new conceptual model for regolith and landscape evolution (p 28)

12.30 *John Field* - Evidence from pedogenesis and regolith formation: Building the landscape evolution story (p 21)

LUNCH and Posters 12.55 - 2.00

Chronologies, bangs and rumbles
Session Coordinator: Trish Fanning

2.00 *Derek Fabel, Jon Harbor, Dennis Dahms, Allan James, Charles Steele, Kelley Daley and David Elmoree* - Reconstructing glacial chronology and spatial patterns of glacial erosion using cosmogenic radionuclides (p 19)

2.25 *Mark Bishop and Vic Gostin* - Process geomorphology of the Mount Schank monogenetic volcanic centre,using a digital elevation model (p 4)

2.50 *Heather Builth* - Dating of the Tyrendarra flow of Mount Eccles in western Victoria and its archaeological context (p 9)

3.15 *Bernie Joyce* - Neotectonics of Western Victoria and adjacent SE Australia (p 32)

3.40 *Phillip Tonkin and Peter Almond* - Using the soil stratigraphy of loess to reconstruct landscape histories of northeastern and western lowlands of South Island, New Zealand (p 55)

Session Coordinator: Larry Frakes

4.00 **AFTERNOON TEA and Special Interest Group Symposium on Palaeochannels**

DINNER at Currency Creek Winery. Bus will leave Conference venue at 7.00 pm

THURSDAY 19th November
FIELD TRIP: Bus leaves Conference venue at 8.30 am

FRIDAY 20th November

Session Coordinator: Jane Soons
Things almost unknown in Australia

9.00 *James Schulmeister, Rob McKay, Christiane Singer and Bill McLea* - Quaternary glacial history of the Cobb Valley and adjacent areas, NW Nelson (p 52)

9.25 *Hamish McGowan* - Results from recent aeolian process studies in the eastern Southern Alps (p 38)

9.50 *Noel Trustrum, Basil Gomez, Michael Page, Leslie Reid, Murray Hicks, Tomomi Marutani and Mike Marden* - Linking magnitude-frequency relations from hillslope to floodplain (p 57)

10.15 *Mike Crozier, N. Preston and S. Brooks* - Event-induced changes to landslide triggering thresholds (p 14)

MORNING TEA 10.40 - 11.00

Fluvial and karst
Session Coordinator: Brian Finlayson

11.00 *Ivars Reinfelds, Paul Bishop and Ian Rutherfurd* - Relative impact of clearing of riparian vegetation, de-snagging, artificial meander cutoffs and high magnitude floods on the morphology of the lower Latrobe River, Gippsland, Victoria. (p 47)

11.25 *Mark Walker and Ian Rutherfurd* - How mobile is your river? Predicting meander migration rates from readily measurable stream variables (p 58)

11.50 *Ken Grimes* - Pans, dolines and other hollows in the Gambier Karst Province, Southern Australia (p 25)

12.15 *Susan White and Lesley Hodgson* - Landform development in Mid Pleistocene dune ridges, Codrington, Southwestern Victoria (p 62)

LUNCH 12.40 - 1.30

FRIDAY 20th November (Cont)

Bugs in the system

Session Coordinator: Mike Crozier

1.30 *Greg Hancock, Gary Willgoose, Dene Moliere, Mike Saynor and Ken Evans* - The validation of a physically based landscape evolution model using experimental, post-mining and natural catchments (p 26)

1.55 *Russell Drysdale* - The geomorphic development of travertines at Lawn Hill, NW Queensland (p 17)

2.20 *Bernie Joyce* - Granite landscapes in SE Australia: Factors influencing elevation,relief, weathering and outcrop (p33)

2.45 *Arjun Heimsath and John Chappell* - Geomorphology of a microbiotic planet (p 27)

AFTERNOON TEA 3.10 -3.35

Final Session Coordinator: Vic Gostin

3.35 *Geoff Humphreys and Russell Field* - Bio-mixing compared to mounding: some geomorphic and pedologic implications (p 30)

4.00 *Kevin Kiernan and Anne McConnell* - Geomorphology of Heard Island (p 36)

POSTERS

Paul Batten - Landscape Unit Mapping Using Digital Elevation Models (p 65)

Bob Bourman, Colin Murray-Wallace, Tony Belperio and Nick Harvey - Dynamic Landform Change in the Murray Mouth Estuary of Australia (p 66)

Paula Crighton, Paul Hesse and Carol Jacobson - The relationship between slope and aspect in the Cullen Bullen area of the Blue Mountains, NSW (p 67)

David Gibson And Roslyn Chan - Aspects of Palaeodrainage in the North Lachlan Fold Belt (p 68)

Susan Greene and Mark Bishop - Landslide hazard analysis using a digital elevation model,Yankalilla, South Australia (p 69)

Kirsten Hennrich And M.J. Crozier - Linking climate, slope hydrology and soil strength (p 70)

Paula Jones - Reservoir Sedimentation as a basis for soil erosion estimates in a semi-arid environment NSW (p 71)

Longyin Li, Brian Finlayson and Stephen Gallagher - The formation of Holocene geomorphic features in Anderson Inlet, Victoria, Australia (p 72)

Lea Moore - Ferruginous concretions from Wilpena Pound, Flinders Ranges, South Australia (p 73)

Victor Tokarev, Vic Gostin and Mike Sandiford - Planation surfaces of the Mount Lofty Ranges (p 74)

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PULLING ROOTS IN GIPPSLAND: THE ROLE OF ROOT REINFORCEMENT ON RIVERBANK STABILITY

Bruce Abernethy and Ian Rutherfurd

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Riparian vegetation exerts a profound influence over riverbank erosion processes. The influence of vegetation, however, depends very much on its type, position on the bank, and position within the stream network. To understand the role of vegetation in stream bank erosion and stability, one must:

a) understand the processes of bank erosion;
b) appreciate that different processes may dominate at different points within the catchment;
c) consider the influence of vegetation on each of the processes;
d) determine those properties of vegetation that affect each of the processes; and
e) quantify the effect of vegetation on the processes acting in different parts of the river system.

The work presented here forms part of a larger study that seeks to tease out the influence of riparian vegetation over bank processes throughout a catchment. This paper concentrates on the role of root reinforcement in bank mass stability.

Banks of the large lowland rivers generally retreat by cyclical combination of toe scour followed by mass failure under gravity, followed then by basal cleanout of failed material. All these components of retreat are affected by bank material properties including, particularly, vegetation. Riparian vegetation affects bank stability both directly, by altering the strength of bank material and indirectly, by interacting with hydraulic, hydrological, geotechnical and morphological characteristics of the bank. Vegetation growing on the outer bank of meander bends, for example, affects both the rate and distribution of bank erosion in a bend. This, in turn, influences the speed and direction of bend migration which in turn dictates the overall pattern of channel evolution.

Bank material reinforced by plant roots behaves as a composite material in which elastic roots of relatively high tensile strength are embedded in a matrix of relatively plastic soil. The magnitude of root reinforcement is a function of root strength and the distribution of roots within the soil. We conducted field and laboratory experiments on two Australian riparian species, River Red Gum (*Eucalyptus camaldulensis*) and Swamp Paperbark (*Melaleuca ericifolia*), to quantify root distribution and strength.

The tensile strengths of individual roots were investigated by both field and laboratory tests. Load and displacement were logged during all tests and the root diameter at point of rupture measured to calculate the root tensile strength at failure. Root distributions were assessed by inspection of a number of profile walls excavated at various distances between the trunk and the canopy dripline. The positions of all roots dissected by the profile walls were mapped onto clear plastic sheets.

The strength data were incorporated into a force equilibrium model to determine the contribution of roots to soil shear strength. The model assumes that shear displacement in the bank mobilises shear stresses between the roots and the soil which develops tensile forces in the roots. Combining the results of the reinforcement model with the root distribution allowed us to express root reinforcement as a function of depth and distance from trunk.

Analysis of the data indicates that even low root densities can provide substantial increases in shear strength compared to non-root-permeated soils. Applying the root reinforcement data to real channel geometry in a slope stability package enabled the effects of root reinforcement to be analysed in the context of other geotechnical considerations such as pore water pressures. Through this modelling exercise we show that the increase in substrate strength due to roots improves bank stability as indicated by higher factors of safety for the vegetated bank sections we tested.

Understanding the geotechnical response of river banks to root reinforcement from native riparian species provides insight into a number of practical and interesting questions. Improving our understanding of bank-processes allows for greater reliability in manipulating or predicting channel form. Such knowledge can be applied to problems as diverse as stream rehabilitation, infrastructure protection or channel evolution theory.

BARRIER TRANSLATION FOR DIFFERENT RATES OF SEA-LEVEL RISE

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Origins of Holocene coastal barrier systems on the Australian East coast are well understood. However, how barrier systems will respond if sea-level rises again is not yet clear. This study focused on the response of NSW coastal sand barriers to different rates and magnitudes of Sea-Level Rise (SLR).

To determine the rate and magnitude of barrier movement, it was important to determine whether variation in offshore slope, barrier width, back-barrier width and dune height and slope, effected barrier translation. To test the sensitivity of each of these parameters to SLR, a range of data were collected from mapping and literature research based on the morphology of the NSW coast. The data was then applied to a computer simulation model, the Shoreface Translation Model (STM) (Cowell *et al*, 1988), to test the relationship between parameter variation and barrier translation. When parameter variability was plotted against barrier translation, highly linear and logarithmic relationships were formed.

However, it is important to note that the individual parameters do not operate in isolation. To determine the interaction of the individual parameters within an entire barrier system, a set of hypothetical barrier profiles were developed based on existing barrier classification schemes for the NSW coast. The STM was then applied and the translation rates of the hypothetical profiles for both anthropogenic SLR, and long term geological rates of SLR, were determined.

Based on these experiments a conceptual model of relative barrier response was developed. This conceptual, schematised model (Figure 1) allows qualitative estimates of barrier translation, under conditions of rising sea level to be determined. The translation rate of any barrier is a direct function of the size and scale of the input parameters (shown on each axis).

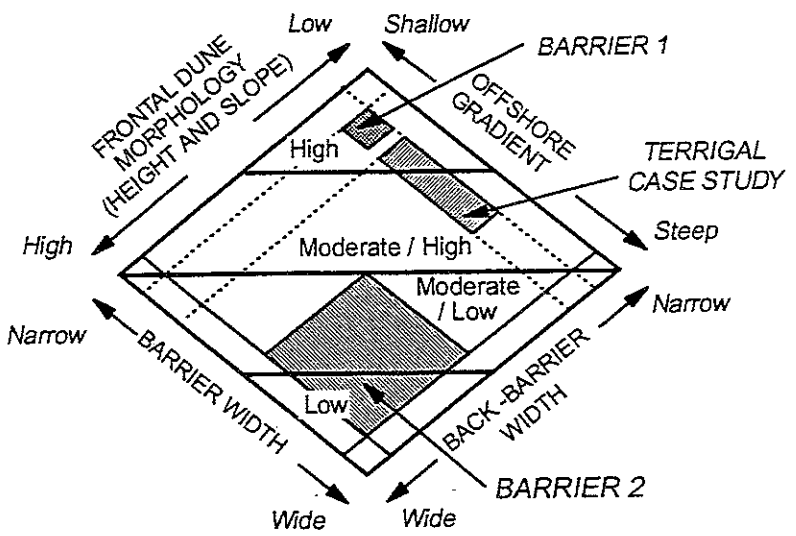

Figure 1: Schematised barrier response model

To validate the schematised barrier response model, empirical data was applied to a complex real-world setting, and run on the STM. The Terrigal barrier system (Central Coast NSW) was used for this study. The results supported the model by showing that variation of the parameters within the single barrier affected barrier translation. However, in addition, this study showed that each of the parameters operate and respond at different time scales. That is, that dune height and barrier width are the dominant factors controlling initial barrier response, and, as sea-level continues to rise, back-barrier width and offshore gradient become increasingly important.

A SYSTEMS ANALYSIS OF THE MORPHOLOGIC EVOLUTION OF THE GURRA GURRA CRESCENTIC DUNES, STRZELECKI DESERT, SOUTH AUSTRALIA

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Desert research throughout both terrestrial and Martian ergs has shown that the genesis and evolution of crescentic dunes are responses to the fundamental parameters of a reliable sediment source, a variable surface roughness and a regional, primary uni-directional aeolian regime. Generally, these factors are also responsible for the form and development of a small field (some 2400 m x 320 m) of crescentic dunes at Gurra Gurra waterhole (29° 01' S, 140° 02' E) in the Strzelecki Desert of north-eastern South Australia. Detailed analyses, however, have shown that the intricate natures of dune micro-morphology and surficial sedimentology are responses to site specific sand sources in a semi-closed geomorphic system. Topographic enhancement and seasonal periodicity of less dominant secondary and tertiary wind directions, strengths and durations, as well as other climatic and vegetative influences, are important variables in the evolution of these dunes (Fig.1). Dune morphology and surficial sedimentology are in continual transition between the dynamic end-members of equilibrium and quasi-equilibrium.

The Gurra Gurra crescentic dunes owe their existence to the dimensional character of an underlying quartz-sand linear dune host. The greater size of the linear dune, relative to others in the region, allows in summer, enhanced oblique upslope wind-speed amplification over the eastern plinth. This, in turn, augments the wind's ability to erode the linear form. Erosion is evidenced by the lowering of the intradune floor with the subsequent formation of yardangs. Yardangs originate in response to venturi flow along polygonal desiccation fractures of a clay-enriched surface. Desiccation caused by the swelling and shrinking of eluviated montmorillinitic laminae amongst the quartz-rich sands, is a primary process that provides a sediment source, and a variable surface roughness. Such processes have lead to significant lowering of the northern relief of the linear dune and to the development of stacked transverse dunes. Dunes of barchan and barchanoid nature originate at the more southern end of the field.

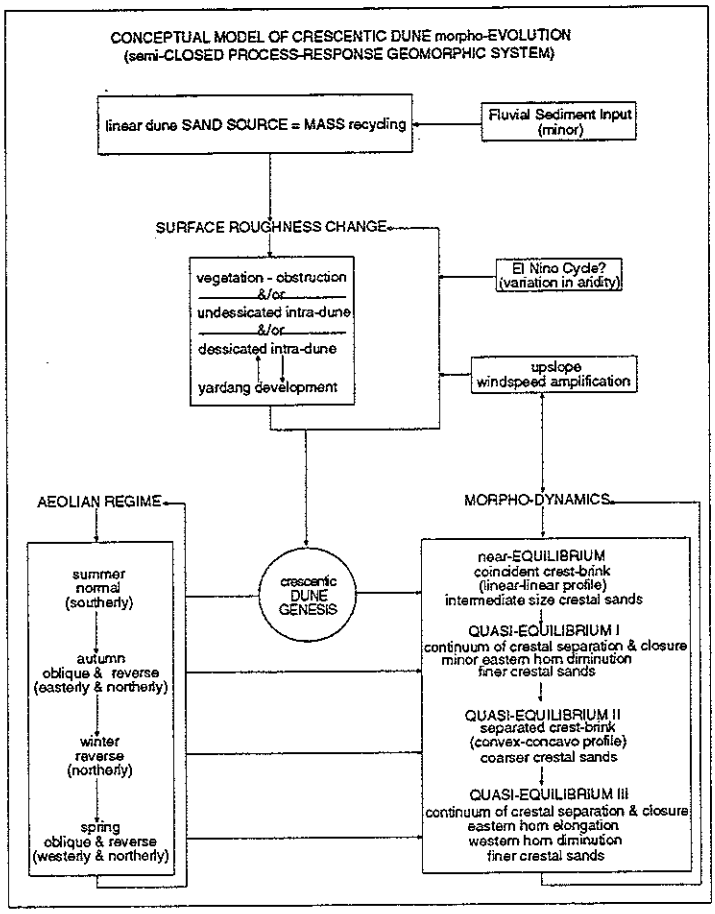

Fig.1. Model of crescentic dune morpho-sedimentologic evolution

PROCESS GEOMORPHOLOGY OF THE MOUNT SCHANK MONOGENETIC VOLCANIC CENTRE USING A DIGITAL ELEVATION MODEL

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The Mount Schank basaltic, monogenetic volcanic centre of south-eastern South Australia, consists of fissure erupted spatter cones, lava flows, hybrid scoria-tuff cones and maar landforms. Both magmatic and phreatomagmatic processes are represented. These volcanoes are most probably the youngest, *ca.* 4,000 - 5,000 years BP, on-shore eruptives of the Cainozoic basaltic province of the Newer Volcanics of SE Australia, and are best described as having formed in an intraplate-continental-plains setting.

Field evidence shows that the volcanic centre was formed by consanguineous eruptives involving exhalative, effusive and explosive eruption sequences. Icelandic-type lava flows, Strombolian-style scoria cone forming and penecontemporaneous phreatomagmatic processes of base-surge and airfall attributed to a complex chronology of events.

The study of eruption processes for Mount Schank has been augmented by the generation of an image of the volcanic complex by way of a Digital Elevation Model (DEM). Using digitised contours and a 3D surface mapping program, SURFER®, the construction and manipulation of the data sets has produced a DEM of successive volcanic landforms. The value of the DEM is the ability to generate morphometric attributes about the terrain, as well as, the ease of interpretation offered by 3D visualisation. The characterisation of general geomorphometry, combined with field data concerning volcaniclastic processes, have defined the crustal depth of the major magma chamber, the depth of interaction between rising magma and groundwater, as well as, the ascent velocity, role of volatiles, and discharge rates of the magma.

Preliminary results for the central edifice of the volcanic centre show a cone some 0.8 km in basal diameter with a cone volume of 2×10^7 m^3, and an effusion rate approximating 20 m^3sec^{-1}. This corresponds to a magma reservoir at a crustal depth of about 2 km. Reservoir depth corresponds with a zone within the quartzose, marginal-marine to fluviodeltaic sediments of the late Cretaceous Sherbrook Group. It is the rise of magma from this storage level and its interaction with groundwater in the overlying Tertiary sediments, that is the driver for phreatomagmatism. The depth of magma-water interaction is considered the control by which base-surge or airfall becomes the dominant process of tephra deposition and, therefore, landform development. The depth of interaction could initially be as deep as 1 km, the maximum onshore thickness of the Tertiary sediments in the Port MacDonnell area, but more likely to have occurred somewhere between 500 m - 100 m, when magma contacted the high-yield groundwater aquifers of the Mepunga Formation and Gambier Limestone. Further modeling of the cone and maar will refine this estimate.

Digital Elevation Models are increasingly becoming an analytical tool of quantitative-process geomorphology. The ability to generate, manipulate, visualise, interpret, and present morphometric data, topographic contours and shaded relief by way of 3D modelling and photorealistic shaded-relief scene rendering, as well as, to re-scale and re-orient the map projection, is highly beneficial to the understanding of the processes involved in the genesis and evolution of a terrane like the Mount Schank volcanic centre.

SEDIMENT TRANSPORT IN LOW-ENERGY RIP CURRENT SYSTEMS

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Sediment transport in rip currents is described based on field observations made at Palm Beach, NSW, Australia in April and June, 1994. Direct measurements of sediment transport using streamer traps mounted on portable racks were made in three low-energy rip currents. Time-averaged sediment flux was found to increase with increasing rip current velocity (u_r) and decreasing depth suggesting that maximum transport is associated with the fastest flowing rips at low tide.

Sediment grain size exhibited a significant fining upwards trend in the rip channel flow with up to 50% of the sediments transported in the bottom 10% of flow. Gross sediment transport rates were found to be strongly related to u^3. Examination of the Shields parameter (θ) indicated that waves are more important than currents in the entrainment of sediments, but that currents are responsible for subsequent transport of the sediments.

Using a Bagnold-type approach as a conceptual basis, net transport in the feeder channel was found to be inhibited at all times during a tidal cycle, whereas offshore transport in the rip-neck occurred at all times. The relative roles of waves and currents in rip sediment transport therefore contributes to the infilling of the feeder channels and incision of the rip-neck channel observed during an almost complete cycle of low-energy intermediate beach state evolution as described by the model of Wright and Short (1984).

KEYWORDS: rip currents, sediment transport, coastal morphodynamics

THE GEOMORPHIC RESPONSE OF RECEIVING STREAMS FOR INTER-BASIN WATER TRANSFER ON THE NORTH COAST OF NSW

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An inter-basin transfer of water to the Nymboida power station on the NSW North Coast has created seven different types of fluvial geomorphic response or "stream behaviour" in the receiving streams: Goolang Creek, Blaxland Creek and the Orara River. Each behaviour relates to a reach-specific combination of slope, bed/bank material, vegetation and human activities such as large woody debris removal.

The releases from the power station have occurred at an increasing duration and frequency since 1924. The water is piped from the Nymboida River and released at a lower elevation into an adjacent small catchment where it is carried by the three receiving streams. Historical records, plans, anecdotes and aerial photographs indicate that there have been major changes to all three streams. This is confirmed by field evidence and a detailed long profile surveyed in late 1997. Receiving stream width has increased by more than 2.5 times and the bed has lowered by more than 2.5 metres in many places. A sediment slug in the Orara River has filled all pools and raised low flow water levels by almost one metre.

In detail, the seven behaviours are described as:

1. Eroding Bed and Slumping Banks: The whole creek bed in the reach is continuing to incise, undermining the toe of the banks and causing extensive bank failure. There is no pool and riffle sequence and banks are generally bare of vegetation. This is occurring in reaches where the bed is composed of sand and small gravel (no armouring) and the banks are composed of alluvium.

2. Eroding Bed with Stable Banks: The channel has already widened to accommodate the releases but erosion of riffles is continuing to destroy the pool and riffle sequence. The result is shallow pools with high flow velocities during the releases and very little instream storage and aquatic habitat. This behaviour is occurring where large gravel particles have reduced the rate of bed erosion due to armouring effects. This caused the banks to erode in the early decades of the releases so that they have had time to become stable and vegetated.

3. Channel Recovering: There is no recent extensive bed or bank erosion although the channel has expanded greatly in the past. Recent formation of islands, bars and a sequence of riffles is raising the general bed level. Deep pools are forming at each bend and above each riffle. In a few places, vegetation-stabilised islands or bars are deflecting flows and eroding the banks.

4. Recovered Channel: Although the channel is much larger than pre-release, the creek bed and banks have been in equilibrium with no accelerated changes for at least the last decade. The banks are well vegetated and a good pool and riffle sequence exists.

5. Rigid Bed and Banks: The presence of bedrock and large boulders has minimised bed and outside bend erosion since the start of power station releases. The channel has widened on the inside bends that lack bedrock but there is no longer any active bank erosion. The banks are well vegetated and the original pool and riffle sequence has been preserved.

6. Sediment Slug Deposition (Orara River immediately downstream of confluence with Blaxland Creek): Large sediment deposits are filling in pools and raising bed levels, maintaining and enlarging a sediment slug. The result is a loss of instream storage and aquatic habitat, decreased channel roughness/capacity and deflection of flows into banks by vegetated bars.

7. Sediment Slug Erosion (Orara River near Poley Bridge): The river is incising the downstream end of the sediment slug and carrying the sand and gravel to the Clarence River (behaviour not studied).

The nature of each stream behaviour type determines what options and priorities can be considered for stream rehabilitation. This includes the control of accelerated erosion rates and the improvement of in-stream habitat for flora and fauna.

EXAMINING THE INFLUENCE OF LANDSCAPE FEATURES ON HILLSLOPE SEDIMENT TRANSPORT IN AN ARID ENVIRONMENT

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This paper discusses results obtained during a five year sediment monitoring programme undertaken at Fowlers Gap in western New South Wales. Primary data were obtained via a network of 56 sediment traps installed to assess the quantity and particle size of material moving downslope. Variations were then assessed as a function of a number of landscape features using multivariate statistical techniques. Landscape features examined included slope angle, percentage vegetation cover, percentage stone cover, and mean stone size, in addition to a number of physical and chemical properties of the regolith.

It is argued that as a landscape evolves particular suites of attributes develop that describe specific locations within that landscape. For example, steep slopes may be characterised as having high levels of coarse stone cover overlying regolith with low exchangeable sodium percentage (ESP) values, while low slope angle sites may display low levels of surface stone cover in which the stones are generally small and overly regolith which has high ESP values. As the landscape features that describe these two theoretical sites are different, it is also likely that the geomorphic processes that occur at these sites also differ. Some process geomorphological investigations, especially those which are undertaken in laboratories, may ignore these variations and use experimental techniques such as tiltable flumes that allow the measurement of the influence of, say, stone cover at a number of different slope angles. The results from these studies, while interesting in their own right, are not directly transferable to the real world as, clearly, landscape evolution would lead to the adjustment of these conditions so that specific stone cover levels were associated with particular slope angle ranges. Much of the ambiguity in the literature regarding just how a particular landscape feature influences erosion may result from differences in experimental technique and differences in the spatial scale of the experiment.

During the present study it was demonstrated that the importance of any individual landscape feature in influencing hillslope sediment transport depends on the way in which the data are examined. For example, the importance of a variable may alter as the size of the storm varies, so that landscape features identified as statistically significant in influencing sediment transport during small storms were considered less influential, or even not significant, during large storms. It was also demonstrated that some variables clearly influence hillslope transport at sites which have steep slope angles, however, these variables are less important at low angled sites. The form in which the data were expressed, that is, whether the sediment collected was expressed in the form of a sediment mass or mean particle size also lead to the identification of different statistically significant landscape features.

The results obtained during this investigation indicate that the relationship between hillslope sediment transport and any individual landscape feature is complex. Results suggest that the relationship will be influenced by the spatial scale at which the study is conducted, the experimental technique used, the size of the storm event that produces the sediment transport, and the geomorphic position of the site in the landscape, in addition to the presence or absence of a suite of landscape features.

THE "PALAEO-TOWAMBA' - A SOUTHEAST FLOWING PALAEOCENE RIVER DRAINING THE MONARO DISTRICT, SOUTHEAST NSW.

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Palaeocene to early Oligocene basalts of the Monaro Volcanic Province cover about 4,000 km^2 of the tablelands of the Monaro district of southeastern NSW, They were erupted from a multitude of volcanic centres, mostly located near the southeast trending Monaro range section of the Great Divide (Brown *et al.*, 1993). The basalts are presently up to 300 m thick in places and were originally thicker. They largely buried a well-dissected landscape with a relief of up to 500 m.

Apart from some thicker flows, the basalt is well weathered and is not particularly resistant to erosion compared with the bedrock of the deformed Palaeozoic sedimentary and acid volcanic rocks and granitoid intrusives. Thus erosion since eruption of the basalts has tended to exhume the Palaeocene landscape allowing reconstruction of much of the Palaeocene drainage network. Drainage lines have been interpreted from elongated outcrops or lines of outliers of basalt or early Tertiary sediments with topographically higher bedrock on either side. Palaeo flow directions have been interpreted from provenance of clasts in gravels, cross bedding in sands, and pebble and cobble imbrication; and less reliably from present slopes and patterns of branching of palaeochannels.

An area of about 5,500 km^2 of the tablelands, including most of the area of the volcanic rocks and areas to the south and west of the volcanic outcrop, formed a major drainage basin with its outlet to the southeast along the present Towamba River valley and a buried valley offshore. This Palaeocene drainage network was more deeply incised and had higher gradients than much of the present drainage in the same area of the Monaro. It was well adjusted to the structure and relative erodability of the bedrock geological units. The main channel followed a major NW-SE fracture system, the Berridale Fault and Towamba Lineament.

Tributary streams draining into the drainage basin from the south and west were dammed by the build up of volcanic rocks to form substantial Late Palaeocene lakes in which thicknesses up to 150 m of laminated muds, sands, gravels and lignites accumulated (Taylor *et al.*, 1990). These streams included the ~~SSE~~ flowing tract of the Snowy River (the "Jindabyne River" of Ollier and Taylor, 1988) and the southeast flowing tract of the Murrumbidgee and tributaries including the east flowing "Adaminaby River" of Ollier and Taylor (1988). Both of these tributary systems were diverted by the build up of basalt. The upper Murrumbidgee was diverted to the east, crossing a Palaeocene divide into a northerly draining stream system; and the "Jindabyne River" was diverted south along the margin of the basalt to cross a divide to the south and join the present NNW-flowing tract of the Snowy River.

Ollier and Taylor (1988) proposed that the sub-basalt drainage of the Monaro was all to the north and northwest, and that their "Adaminaby" and "Jindabyne" rivers were reversed by Miocene uplift in the west, well after eruption of the basalts, and that they then flowed around the margins of the older pile of volcanics to give the present drainage configurations. The "Jindabyne" was certainly flowing in its present direction in the late Palaeocene. There is room for doubt about the Palaeocene flow direction of the "Adaminaby", but I interpret it as a tributary of the "Palaeo-Towamba" system.

There may have been an ancestral north and northwesterly flowing drainage system in the area of the Monaro Volcanic Province as proposed by Ollier and Taylor (1988); but if so, much of it had already been captured, diverted or reversed, and was already draining to the southeast by the late Palaeocene, before eruption of the basalts.

Brown, M.C., McQueen, K.G., Roach, I.C. and Taylor, G. (1993) Excursion guide to the Monaro Volcanic Province. *Australian Geological Survey Organisation, Record* 1993/61.

Ollier, C.D. and Taylor, D. (1988) Major geomorphic features of the Kosciusko-Bega region. *BMR Journal of Australian Geology and Geophysics*, 10: 357-362.

Taylor, G., Truswell, E.M., McQueen, K.G. and Brown, M.C. (1990) Early Tertiary palaeogeography, landform evolution and palaeoclimates of the Southern Monaro, NSW, Australia. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 78: 109-134.

DATING OF THE TYRENDARRA FLOW OF MT ECCLES IN WESTERN VICTORIA AND ITS ARCHAEOLOGICAL CONTEXT.

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The Mt Eccles and Mt. Napier volcanoes, in western Victoria, between them produced the most extensive and diverse collection of volcanic features in south-eastern Australia (Context, 1993). The Mt Eccles lava flow, in addition to being one of the longest and most distinct in Victoria, is also of enormous archaeological significance (Builth, 1996) and the subject of current postgraduate research at Flinders University. The nexus between geological events and cultural connections are highly-significant to present day Gunditjmara, with consequences in archaeological interpretation.

The most recent suggested date of 27,000 years BP for the last eruption of Mt Eccles (Head, D'Costa and Edney, 1991) was based on analysis of core samples taken from swamps adjacent to the lava flow. This date is considerably older than previous estimations by Boutakoff (1963), Gill (1979) and Ollier (1981) and is generally accepted by archaeologists as the date for the last eruption. The reasons for an apparent dearth of late Pleistocene-early Holocene sites in the area, as observed by Head, D'Costa and Edney (1991), might be explained if a more recent Holocene eruption had taken place.

The suggestion by Head, D'Costa and Edney (1991) that a lava flow blocked drainage and resulted in wetlands 27,000 years ago is now open to re-interpretation based on recent findings. It may represent an older flow that was responsible for the formation of a large lake. This lake existed until approximately 8,000 years BP when another eruption facilitated its drainage, subsequent formation of the Condah Swamp and the newly-formed Lake Condah. The transition from lake mud to peat in the Condah Swamp occurred between 8000-9,000 years BP. Observation of this transition in core, ignored by previous workers, supports this latest interpretation.

This chain of events is not inconsistent with Ollier (1981) in that there could have been two distinct volcanic events at about 20,000 and 7,000 years ago. There is also evidence to suggest that a younger flow approximately 8,000 years BP did not extend the entire length of the previous flow. This younger flow, however, did present a new landform and physical environment for cultural occupation by the Gunditjmara, and quite possibly destroyed previous occupational evidence.

References:

Boutakoff, N. 1963. 'The geology and geomorphology of the Portland area' Memoir no22, *Geological Survey of Victoria, Dept. of Minerals and Energy:* Melbourne.

Builth, H. 1996. *'Lake Condah revisited: Archaeological Constructions of a Cultural Landscape'*_ Unpublished Honours thesis. University of S.A. (AboriginalStudies).

CONTEXT, 1993. *'Lake Condah - Heritage Management Plan and Strategy'*_ Aboriginal Affairs Victoria: Melbourne.

Gill, E.D., 1979. 'The Tyrendarra lava flow, western Victoria, Australia', *Victorian Naturalist*_ 96:227-229

Ollier, C.D., 1981. 'A buried soil at Mt Eccles' *Victorian Naturalist*_98:195-199

CHEMICAL GEOMORPHOLOGY: WHAT CAME DOWN IN THE LAST SHOWER (OR THE AIRBORNE RETURN OF MARINE SOLUTES TO THE CONTINENTS).

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Much has been written concerning the generation of solutes during terrestrial weathering reactions. The ultimate fate of such solutes lies in the oceans although solute reservoirs also occur in terminal, commonly playa, lakes. The chemistry of playa solutes is commonly held to be a function of the composition of the hinterland rocks that are undergoing weathering reactions. However, the solutes of the playas, groundwaters and soil waters from the larger desert areas of the world, for example, in Africa, Australia, and some parts of Asia, reveal major-and some trace-element compositions very close to those of seawater. This has raised the notion of "cyclic salts", namely, the airborne return of substantial quantities of marine solutes to the continents.

The tracing of such materials is not possible with major-element chemistry, nor with oxygen-18/deuterium data. However, the problem can be addressed using the stable isotopes of sulphur, boron, and carbon coupled with $^{87}Sr/^{86}Sr$. calcium isotopes and chlorine-36. A substantial study of terrestrially accumulated solutes in Australia with contrasting examples from the Dead Sea, Israel, and the Qaidam Basin, China, has been partially completed, with results on sulphur [1], boron [2,3,4,5,6], carbon [7], calcium [8], and chlorine [9] at hand; additional new information is presented here.

The sulphur isotopic composition of groundwaters and playa gypsum from western and central Australia defines a continental pattern with $\delta^{34}S$ values of up to +23% CDT at coastlines, with values that decrease in a progressive manner to +14% near the centre of the continent, irrespective of underlying basement rock types or ages. This contemporary $\delta^{34}S$ pattern of surficial sulphate is interpreted to represent the delivery of airborne marine sulphate (+21% CDT), with lesser amounts of sulphate derived from the oxidation of dimethyl sulphide. Bedrock sulphur contributes little to the surficial sulphate budget except over sulphur-rich rock types such as pyritic shales or near sulphur-rich ore deposits.

A west-east traverse of $^{36}Cl/Cl$ measurement from playa halite across Western Australia reveals values that increase monotonously away from the Indian Ocean coastline and mimic, but at lower values, measured $^{36}Cl/Cl$ values in contemporary rainfall. Again the relationship with relatively modern processes suggest a marine-aerosol source for continental surficial chloride [10]. Based on a half-life of 301,000 yr for ^{36}Cl, a mean residence time of about 0.75 Ma can be suggested for Western Australian terrestrial chloride. Boron isotopes have been used to distinguish between marine and non-marine evaporites with evaporites that receive boron from the weathering of continental rocks, particularly granites (eg. Qaidam Basin China) reflecting typical continental crustal boron values of $\delta^{11}B$~0‰, whereas marine evaporites may relate to $d^{11}B$ values of ~40‰. However, evaporites and brines from Australian salt lakes have $\delta^{11}B$ values up to 65‰, most readily explained by a "second cycle" of brine-sediment interaction resulting from marine aerosolic boron being adsorbed onto clastic sediments within the playa basins. There are also clear isotopic and chemical indications that some principal chemical components of the Australian surface are derived from sources other than marine aerosols. At least part of the calcium can be shown to be bedrock-derived, at least on Archaean terranes, and carbon in calcretes has a dominant origin related to past vegetation.

The overall conclusions of this work establish that drier continents preserve a record of solute transport from the oceans to the continents that is more difficult to detect in humid continents. Fundamental questions also arise concerning origin of soil salinization particularly in semi-arid zones and the strategies to be adopted for agricultural management in salt-affected soils. Also, the identification of marine vs terrestrial evaporites through geological time now becomes blurred given another class of terrestrially-hosted evaporites with "marine" chemical and isotopic signatures. These discoveries have a profound effect on our understanding of geomorphic processes in the Australian arid-zone and of the interpretation of palaeoclimatic information. The dominant sources of the elements S, Sr, Ca, Cl and B to the Australian landscape, even at large distances from modern coastlines, is related to marine aerosols and reworked dust. Thus the principal chemical components of Australian salt lakes and pedogenic carbonates and gypcretes are derived from sources external to the continent.

References: [1] Chivas A.R., Andrew, A.S., Lyons W.B., Bird, M.I. and Donnelly T.H. (1991), *Palaeogeogr., Palaeoclimatol., Palaeoecol.*, 84, 309-332. [2] Vengosh, A., Chivas, A.R., McCulloch, M.T., Starinsky, A. and Kolodny, Y. (1991), *Geochim. Cosmochim. Acta,* 55, 2591-2606. [3] Vengosh, A., Chivas, A.R., Starinsky, A., Kolodny, Y., Zhang, B. and Zhang, P. (1995), *Chem. Geol.* 120, 135-154. [4] Vengosh, A., Starinsky, A., Kolodny, Y. and Chivas, A.R. (1991), *Geochim. Cosmochim. Acta.,* 55, 1689-1695. [5] Vengosh, A., Starinsky, A., Kolodny, Y. and Chivas, A.R. (1994), *J. Hydrology,* 162 155-169. [6] Vengosh, A., Starinsky, A., Kolodny, Y., Chivas, A.R. and Raab, M. (1992), *Geology,* 20, 799-802. [7] Quade, J., Chivas, A.R. and McCulloch, M.T. (1995), *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 113, 103-117. [8] Nelson, D.R. and McCulloch, M.T. (1989), *Chem. Geol.* 79, 275-293. [9] Chivas, A.R., Keywood, M.D., Fifield, L.K and Allan, G.L. (1996), *Geol. Soc. Australia,* abstracts vol. 41, 86. [10] Keywood, M.D., Fifield, L.K., Chivas, A.R. and Cresswell, R.G. (1998), *J. Geophys. Res.,* 103, 8281-8286.

RELATIONSHIPS BETWEEN HILLSLOPE FORM, SOIL PRODUCTION AND TRANSPORT

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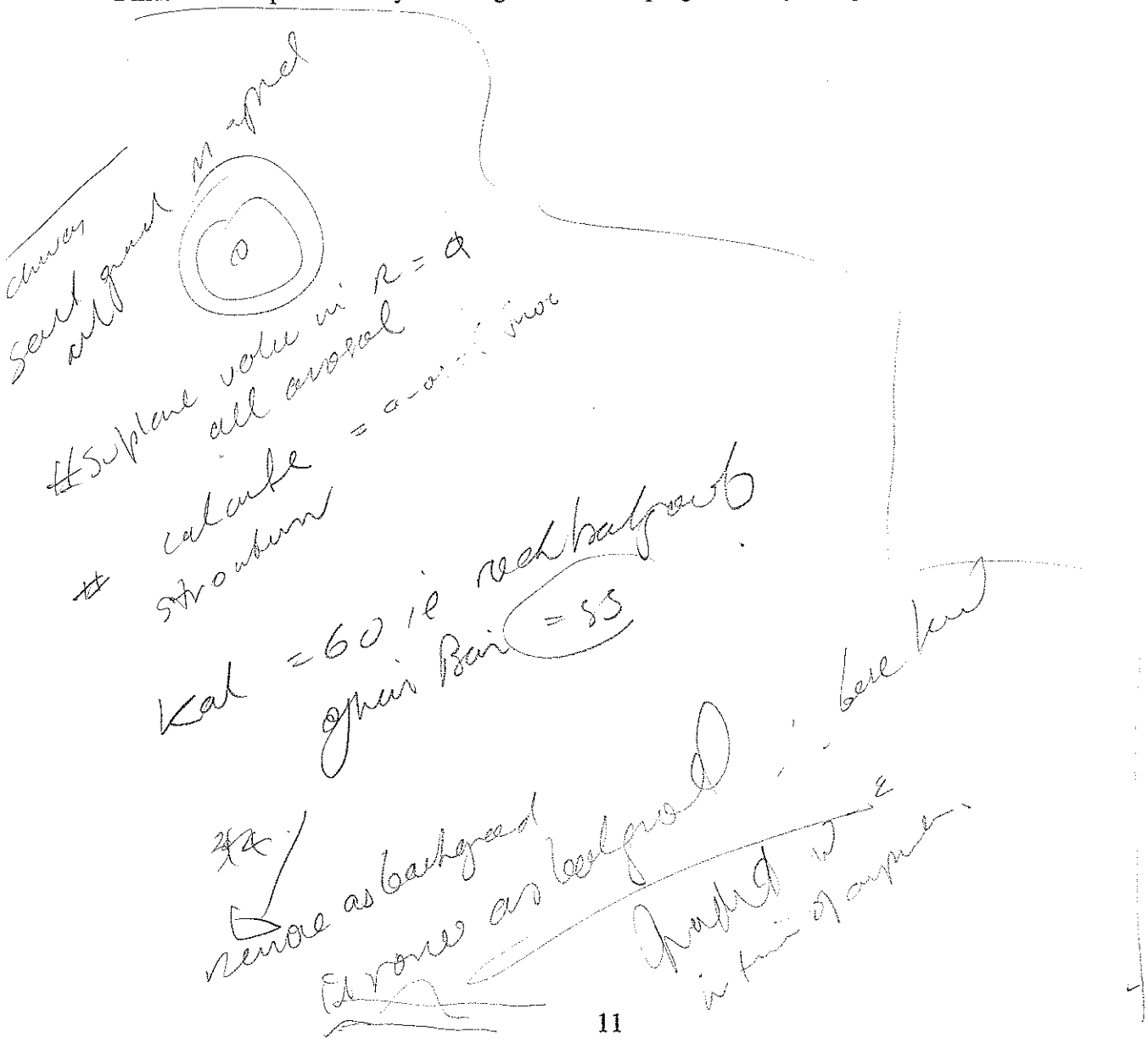
ABSTRACT

Hillslope evolution is computed for a range of soil transport and soil production processes, to discover whether processes can be identified from profiles of slope form and soil depth alone. Transport processes considered here are literature-based models for soil creep by diffusive, viscous or plastic flow, as well as slopewash. Soil production was assumed to decrease exponentially with depth, as determined by Heimsath *et al.*(1997) from ^{10}Be, ^{26}Al studies. Differential equations representing continuity with transport and production process were computed by finite difference methods, with various initial and boundary conditions. Slopes evolving under different processes have different relationships between soil thickness (h) and slope curvature (d2z/dx2), and some but not all evolve to equilibrium slopes of uniform soil thickness. Diffusive and slopewash clearly are distinguishable but slopes generated by other processes are less so.



CHANNEL INSTABILITY IN A FORESTED CATCHMENT: A CASE STUDY FROM JONES CREEK, EAST GIPPSLAND, AUSTRALIA

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To date nearly all studies on the geomorphology of rivers in southeastern Australia have been framed in landscapes which have been dramatically altered in the period following European settlement. Jones Creek, a fifth order stream in a forested sub-catchment of the Genoa River, Victoria, Australia, drains an area of 30 km^2. This tributary has undergone channel metamorphosis triggered by a series of floods between 1971 and 1978 and provides an opportunity to asses a destabilised channel in a forested setting.

Channel widening of the trunk stream by up to 200% at the confluence of Jones Creek in 1971 resulted in a lagged tributary response initiating significant changes in channel form in the alluvial section. Channel incision and bed steepening is seen as the dominant control on subsequent changes in channel morphology within Jones Creek. Three phases of channel adjustment have been identified as the tributary adjusted to a new hydraulic regime. Initial incision resulted in increased stream power while sinuosity was maintained. this has subsequently been followed by phases of channel widening with a reduction in sinuosity. Estimated stream power remains high as the channel continues to go through a phase of lateral adjustment.

This study highlights the dynamic nature of tributary-trunk stream relationships in a cut-and-fill landscape of southeastern Australia. It also demonstrates the variability of morphological processes to channel instability in a forested catchment and provides an assessment of natural recovery mechanisms in a southeastern Australian landscape.

SEM ANALYSIS OF QUARTZ SAND GRAINS AS A METHOD OF DISTINGUISHING ALLUVIAL AND AEOLIAN SEDIMENTS FROM THE NORTH EAST DESERT REGION OF SOUTH AUSTRALIA

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The north east desert region is situated in the western part of the Great Artesian Basin. The landscape of the present environment consists of dunefields, playa lakes, claypans and ephemeral channel patterns and contemporary rivers and creeks. The principal study area consists of Cooper Creek downstream of the Innamincka Dome region, where the creek deposits its sediment as a very large, low-angle 'fan'.

Still a single channel, eventually Cooper Creek branches off into two channels, one flowing to Coongie Lakes and the other flowing into Lake Eyre. The beginning of Strzelecki Creek appears to have been blocked at Innamincka and is not directly connected to Cooper Creek. Water does however enter the southern part of the Cooper 'fan' flowing down to Strzelecki Creek during major flooding events approximately every 7-10 years.

Scanning Electron Microscopy (SEM) analysis of surface features of quartz grains provides evidence of processes acting upon the grains, the original depositional environment and transportation of these sediments in relation to the present depositional environment. The majority of papers utilising SEM analysis of similar sediments have found that aeolian sediments are well-rounded, frosted, opaque and of dull appearances in contrast with the shinny, polished, sub-angular appearance of fluvial sediments. This is in contrast to an analysis of aeolian quartz grain sediments obtained from the north east desert region compared to fluvial sediments of the same region. The lack of rounding in the Strzelecki Desert aeolian sediments could be proportionally related to dune geomorphology, where the dunefield is characterised by longitudinal dunes formed by unidirectional winds which fixed the dunes in one direction.

EVENT-INDUCED CHANGES TO LANDSLIDE TRIGGERING THRESHOLDS

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Rainstorm-triggered landslide events alter terrain conditions sufficiently to affect susceptibility to future landsliding. In one hill country catchment changes to inherent resistance (measured by the factor of safety) resulting from a major event indicate, in future, small triggering rainstorms would be more effective in producing landslides while moderate to large storms would be less effective.

The mechanisms responsible for changes in inherent resistance include mass movement-induced redistribution of regolith, changes to regolith properties, changes in regolith depth and the development of unsupported erosional scarps. The influence of these mechanisms on susceptibility of typical slopes has been investigated and quantified by the use of a combined hydrological slope stability computer simulation model. The net effect is expressed in terms of time to failure and total rainfall required to trigger movement.

LATE QUATERNARY EVOLUTION OF STREAKY BAY, SOUTH AUSTRALIA: RELATIVE SEALEVELS AND TIMING.

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Streaky Bay is a large embayment on the west coast of Eyre Peninsula, South Australia. It is partially protected from high wave attack and swells by headlands and small islands at the mouth. The headlands are composed of Pleistocene Bridgewater Formation aeolianites with an exposed basement of Proterozoic felsic intrusives to the north and south of the bay. The Middle Pleistocene Glanville Formation is found as outcrop in isolated areas around the perimeter of the bay. Two areas (Flagstaff Landing and Point Gibson) in particular have sufficient outcrop and stratigraphic/paleontological control that their depositional characteristics could be surveyed in conjunction with proximal modern beach profiles.

The Flagstaff Landing section varies in thickness from 4 to 80 cm. The formation is composed of fine to very coarse bioclastic sand with abundant fauna which indicates an open marine depositional setting, ie. *Anadara, Katelysia, Chlamys, Glycymeris, Turbo, Haliotis*, and the colonial coral *Goniopora*.. It also contains rounded granules to cobbles of calcrete. The formation lies unconformably on an eroded calcrete within the coeval Bridgewater Formation and is bound on its upper surface by a calcrete up to 20 cm thick. The section represents an upper sandy berm (high tide) grading along section to a cobble sand at an inferred mid to low tide point. It can be correlated with the depositional style of the adjacent modern beach profile. The height difference in the two profile sets averages 1.79 m.

The Point Gibson outcrop, which is on a slope leading down to the bay, is expressed as an onlap deposit on calcrete and aeolianite of the Bridgewater Formation. Thickness is not readily apparent but the depositional environments grade upwards from below low tide to a mid tide level. The low tide level is marked by articulated *Anadara trapezia* and *Katelysia rhytipora* valves. The mid tide region is represented by abraded to fresh shells in a bioclastic medium to fine sand. A narrow Holocene supra-tidal flat lies below this outcrop. This flat is dissected by channels up to 50 cm deep. These lead to a small low energy embayment behind a migrating spit on the southern margin of the bay. The height difference between the low tide depositional environments is 1.82 m. The timing of the Glanville incursion at Streaky Bay is estimated by U-Th series dating at 124±9 Ka BP. This dating was carried out by H.Veeh on the coral, *Goniopora somaliensis*, which is now restricted to north of Moreton Bay, Queensland.

The Holocene St. Kilda Formation at Streaky Bay is present in a range of diverse environments. Skeletal sands from the North Bank, South Sand and marginal dune systems. Organic shelly muds from the subtidal/ intertidal sandflats, mangrove woodlands and samphire flats at Acraman Creek and Point Gibson embayment. The supra-extratidal flats at Acraman Creek are composed of calcareous to gypsiferous muds. These infilling sediments have been determined as beginning 6800 years BP. at Tourville Bay, near Ceduna (Belperio *et al.*, 1988). The radiocarbon dates were derived from subtidal *Posidonia* sea-grass in the sediments. This date suggests sediment accumulation and progradation were relatively rapid and mostly occurring within the first 2000 years of the Holocene still-stand.

Radiocarbon AMS dates from marine and estuarine sediments in Streaky Bay show that up to 2.5 m of sediment has accumulated within the last 3500 years. Relatively rapid rates of deposition (0.05-0.08 cm/yr.) occurred in the Port Gibson area between 3500 and 3200 years BP and between 3000 and 2400 years BP at Acraman Creek. They are comparable with the typical rates that are currently accumulating on the adjacent open shelf

Cores of up to 54 cm were obtained from the inner marginal basins by gravity corer. Carbon-14 dates from the shells in the marine mud sediments collected in the corer indicate low rates of accumulation (0.007- 0.013 $cmyr^{-1}$.). A maximum C^{14} date of 7550 years was obtained from an articulated *Tellina* sp. valve. This suggests that the central tidal deltas in Streaky Bay must have been significantly lower than now, to allow marine conditions to exist in the inner marginal basins. Using the South Australian generalised sea-level curve for 7000 years BP (Belperio *et al.*, 1988), there would have been a relative sealevel of approximately -10 m, inferring that the basins may have had channels to the open sea. These channels provided the access for the sea during the last transgression. Core samples from the sands underlying the rich organic muds of the mangrove areas give Post Modern ages, indicating that the mangrove woodlands of Point Gibson and Acraman Creek became established recently.

• Acknowledgments to ANSTO - Grant No.95/ 84 for AMS C^{14} data.

THE DISTRIBUTION OF NEARSHORE BED MORPHOLOGIES ON SHELTERED, SANDY BEACHES IN SOUTHWESTERN AUSTRALIA

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Knowledge of the nearshore environments in which specific bedforms exist, including their thresholds of formation and destruction, is important for: identification of sandy beach systems that are morphologically dissimilar; determination of specific bedform constraints on sediment suspension processes; and interpretation of ancient wave conditions from stratigraphic records.

The sheltered low energy micro-tidal nearshore environments of southwestern Australia provide ideal sites for the concurrent measurement of bedform morphologies, hydrodynamics and sediment suspension. A portable instrument pod for measurement of currents, waves and suspended sediment concentrations was deployed at 3-5 cross-shore locations on 15 different sandy beaches. Free divers measured the associated cross-shore changes in bedform morphologies.

Two distinct sequences of cross-shore ripple morphologies were observed. The first nearshore sequence, from shallow to deeper water, consisted of plane bed-parallel ephemeral ripples-cross ripples-chaotic ripples and the second type consisted mainly of parallel ripples and parallel ripples with bifurcations. The distinct morphological ripple types were further divided on the basis of their relationship to the bottom boundary conditions, grain size and the associated process of sediment suspension. Significant differences in suspended sediment concentrations were found over different bedform patterns under similar incident wave conditions.

THE GEOMORPHIC DEVELOPMENT OF TRAVERTINES AT LAWN HILL, NORTHWEST QUEENSLAND

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Travertines are secondary calcium carbonate deposits precipitated from rising groundwaters in karst, artesian and geothermal environments. In the Lawn Hill region, northwest Queensland, several perennial streams draining the northeastern portion of the Barkly karst deposit travertines, producing barrages, cascades and pools. One barrage, Indarri Falls, exceeds 13 metres in height and, along with downstream travertine deposits, has transformed Lawn Hill Creek into a series of deep, linear waterholes of up to 30 m depth. Whilst the longitudinal distribution of travertines in the region is controlled largely by the chemical evolution of the depositing waters, the initiation, morphology, growth rate and evolution of the travertines are dependent upon purely hydrological and biological elements once suitable hydrochemical conditions are attained.

Barrage development is controlled by hydraulics and riverine vegetation, and is best observed following wet season floods. Such floods annually scour existing travertine barrages and forge new flow paths around their flanks, effectively exposing a fresh substrate for travertine barrage initiation. Throughout the dry season, small debris dams form and become progressively cemented in place by calcite, which precipitates from the highly turbulent waters. If these 'proto-barrages' successfully weather the next wet season floods, they will be strengthened by cementation during the following dry season and become a nucleus for more substantial barrage development. The growth of travertine barrages proceeds most rapidly at the crest and the downstream face; growth rates in pools impounded by the barrages themselves are very low. Gross barrage accretion thus advances vertically and in the downstream direction. Impounded pools become sediment traps. These sediments are colonised by microbes and develop a calcite crust that may evolve into stromatolitic travertines.

At the barrage surface, aquatic invertebrates and cyanobacteria perform critical microscale geomorphic work. Caddis-fly larvae, especially of the genus *Cheumatopsyche,* erect food nets which increase microturbulence and act as nuclei for calcite precipitation. These fauna also harvest travertine chunks from the barrage surface to build retreats - an unusual case of bioerosion. Filamentous cyanobacteria dominate the travertines and provide substrata for crystal nucleation and growth; they may also directly contribute to calcite precipitation by extracting bicarbonate from the water for photosynthesis. The growth habit of colonies controls the direction in which crystallisation proceeds, and hence the microscale development of the travertine. Upright growth habits (i.e. perpendicular to the substrate) give rise to rapidly accreting but generally porous microbial travertines whilst lateral growth habits yield denser deposits.

THE EFFECTS OF PLANT LITTER ON SEDIMENT DETACHMENT AND TRANSPORT IN THE ARID ZONE: RAINFALL SIMULATION EXPERIMENTS AT FOWLERS GAP, NSW

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Plant canopy cover is not extensive in drylands, commonly amounting to no more than 30%. Inter-plant spaces amounting to 70-80% of the landscape may be occupied by bare regolith surfaces, or surfaces partially mantled by gibbers, microphyte plant communities (mosses, lichens, cyanobacteria, etc) or by plant litter and other organic detritus. Runoff and sediment entrainment on desert surfaces occur primarily in these inter-plant spaces, because canopy interception and enhanced infiltrability of soils near plants, arising from such factors as higher levels of organic matter and faunal burrowing, reduce the incidence and amount of raindrop splash and surface runoff. Furthermore, many dryland shrubs sit on pedestals of splashed soil, which ensures that they are partially bypassed by surface runoff from upslope.

The role of surface properties in plant interspaces is not well researched and has proven to be difficult to unravel using experimental data and multivariate statistical methods. In particular, the effects of plant litter have not been the subject of experimental investigation, even though plant interspaces may have 5-50% surface litter cover. Field experiments were run to investigate the effects of varying litter cover. This was done by adding known amounts of locally sourced plant litter, washed to remove any attached sediment, to 1 m^2 exposed to simulated rain. Litter loadings of 100 g/m^2 and 200 g/m^2 were used, while other plots were studied in their unmodified state to provide controls. Simulated rain generated by a rotating-disk simulator was applied at a design intensity of 30 mm hr^{-1}. Runoff rate was measured by volumetric gauging at 2 minute intervals, and runoff samples were collected at intervals for the determination of sediment concentrations. Plot surface characteristics were recorded from overhead photographs, and included plant canopy cover, litter cover, stone cover and proportion of bare soil. Plot slope was also recorded.

Runoff hydrographs were found to vary in form with litter loading. Highest loadings (equivalent to 2 t ha^{-1}) resulted in rising limbs that showed repeated fluctuations in flow rate with stepped declines and rises in discharge. These were smaller at the lower litter loading (1 t ha^{-1}) and virtually absent on unmodified plots. Litter cover was found to be dynamic during the rain application and declined by up to 20% during the experiments. Litter was thus concentrated within the plot, leaving patches of bare surface bounded by litter accumulations.

Sediment concentrations were unexpectedly found to increase with the amount of litter added to experimental plots. The reason for this is not entirely clear and various possibilities require investigation. A plausible hypothesis is that the litter particles are moved by splash and flow, on which most litter floats readily, into small clusters bordering bare surfaces. These litter clumps serve to hold additional water on the plot surface in the form of deeper ponds than would be present without the added litter. Raindrop splash is thus enhanced in these pools by the shear and other forces created as impact craters form and collapse, as suggested by numerical models of the drop splash process. Prior experimental studies of straw mulch on agricultural soils have suggested a similar effect. If the data are correctly interpreted it seems that the effects of surface litter are more complex than a straightforward protection of the surface from drop impact and flow scour, as is often presumed to be the case. Litter loadings of up to about 2 t ha^{-a} appear to make surface more vulnerable to splash, while loadings above this provide increasing protection of the surface. Litter loadings appear to be a parameter worthy of additional study in the context of dryland hydrologic and erosional response, as well as in rangelend condition assessment.

RECONSTRUCTING GLACIAL CHRONOLOGY AND SPATIAL PATTERNS OF GLACIAL EROSION USING COSMOGENIC RADIONUCLIDES

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Cosmogenic radionuclides are produced at depth in a rock surface at known density dependent rates, allowing the calculation of cosmogenic radionuclide depth profile for any given surface exposure time. This in turn provides information about past erosion. Erosion of a rock surface can remove the top portion of the cosmogenic radionuclide depth profile. By reconstructing the profile it is possible to estimate the depth and rate of rock loss.

We are using this technique to address a classic issue in mountain geomorphology - the spatial pattern of valley scale glacial erosion. For over a century scientists have debated the fundamental geomorphological issue of the spatial patterns of erosion required to produce classic glacial landforms such as U-shaped valleys. This debate has been coupled with discussion of the mechanics of processes that might give rise to such erosion patterns. A major constraint in these debates has been the lack of any reliable way to know what the actual pattern of bedrock loss has been. Although we can map the present-day topography, the pre-glacial form is largely unknown and so any attempt to derive an erosion pattern from landscape change is entirely dependent on speculation about the pre-glacial topography.

Using cosmogenic radionuclide techniques, it is theoretically possible to go to a glaciated valley and measure bedrock loss at multiple locations to derive the spatial pattern of erosion. We commenced an intensive sampling program in the Middle Popo Agie drainage, Wind River Range, Wyoming, and the South Yuba drainage, Sierra Nevada, California. The first set of ^{10}Be and ^{26}Al results from alpine valley cross-sections indicate highly variable down valley erosion patterns.

Due to the nature of cosmogenic radionuclide data we can also speculate on the glacial chronology for the sample sites. Tentative initial interpretation of the available data suggests that up to 200 m thick, boulder carrying ice occupied the Popo Agie valley in the Wind River Range at about 16+/-2 ka. Boulder carrying, erosive ice was also present at high elevations in the Sierra Nevada field area at this time. The implications of this and the spatial patterns of erosion will be discussed.

LANDSCAPE AND LIVING PLACE: ASSOCIATIONS BETWEEN LANDFORM FEATURES AND ABORIGINAL CAMP SITES IN FAR WESTERN NSW DURING THE LATE HOLOCENE

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Studies of surface scatters of Aboriginal stone artefacts are currently being conducted in Sturt National Park in arid far western NSW, under the auspices of an ARC Collaborative Grant project between the NSW National Parks and Wildlife Service and the Dept of Archaeology at La Trobe University. One of the aims is to develop a predictive model of artefact distribution that can be used as a basis for developing Plans of Management for the national park and its cultural heritage. This paper focuses on some of the geomorphic aspects of this work, especially the spatial associations of artefact concentrations and clusters of hearths with landscape features along Stud Creek, an ephemeral valley floor gully draining a catchment of about 30 km^2 within the park. A temporal framework for these associations will also be outlined.

Dense concentrations (up to 40 artefacts per m^2) of stone artefacts are found on the margins of the valley floors in association with clusters of hearths. Three such concentrations, hereafter referred to as Stud1, Stud2 and Stud3, have been identified along Stud Creek. A total of 52,812 artefacts have been surveyed from Stud1 and Stud2 using piece proveniencing methods, while a further 8,021 artefacts between the two sites were located and described using systematic sampling techniques. The artefacts at Stud3 are yet to be recorded.

Artefact exposure is related to geomorphic processes of erosion and deposition which have occurred since they were discarded, and especially since the introduction of pastoralism by European settlers in the mid 1800s. It has been controlled for in this project by geomorphic mapping at both the macro (landform unit) and micro (landsurface condition) scales. Assemblage analysis suggests that the concentrations described above are a product of co-location of occupation through time. In addition, they appear to be spatially associated with particular landscape features. Each campsite is located on the eroding valley floor margin adjacent to a bedrock bar or knickpoint exposed by contemporary valley floor gullying. Clay-rich sediments are exposed in the gully walls and floors immediately upstream of the bedrock bars. Similar sediments are currently being deposited in pools that form following streamflow events in some of the larger creek systems in the region. Such pools or waterholes may have formed behind the bedrock bars associated with Stud1, Stud2 and Stud3, providing a source of water for Aboriginal people camping nearby. They have since been destroyed by incision, channel widening and knickpoint retreat which followed European settlement.

The clusters of hearths are in fact the remains of earth ovens. Aboriginal people in the past scooped shallow holes in the topsoil, lit a fire and added stones to act as heat retainers. Food was then buried in these ovens and allowed to cook. Archaeologically the remains of these ovens are quite distinct. Severe surface erosion caused in part by European pastoralist practices has removed the fine sediments (sands and clays) into which the ovens were dug, such that today the shallow pit no longer remains. Instead, the oven-stones and deposits of charcoal that they protect are pedestalled above the current land surface, in a form of relief inversion. A total of 72 oven-like features have been identified in the study area. Two have proved on excavation to be burnt tree roots. A further 40 did not provide sufficient charcoal with which to obtain a date. Of the remaining 30, 15 have been dated by the University of Waikato Radiocarbon Dating Laboratory using conventional methods and the remainder are awaiting processing. The dates obtained so far, when calibrated, fall into four clusters separated by gaps of one to four centuries, extending from 430 y BP back to 1500 y BP. This interesting and unexpected result has significant implications for Aboriginal occupation and patterns of resource use in the arid zone in the late Holocene.

EVIDENCE FROM PEDOGENESIS AND REGOLITH FORMATION: BUILDING THE LANDSCAPE EVOLUTION STORY.

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There are many ways in which the history of landscape evolution is recorded in the regolith and soil horizons. Broad measures such as rates of denudation can be estimated from rates of weathering and erosion; periods of erosion and deposition are recorded within soil profiles; the presence of relict mineralogy such as laterite, silcrete, calcrete or bauxite is evidence of different past climates and weathering pathways suggest past climate conditions; mineralogy can provide evidence of past aeolian sources as can particle size analysis; and soil micromorphology often contains ghosts of past events and processes. Each of these can be illustrated by a case study.

As a result of geochemical weathering analyses and the use of indicator minerals minimum rates of chemical breakdown, loss of mass and concomitant loss of volume can be calculated. On three research catchments near Armidale, NSW rates of weathering and erosion were calculated and these gave rates of denudation under temperate vegetated conditions that range from 1 mm in a dry period on granite soils to 14 mm in a wet period on basalt per 1000 years. The problem with this set of calculations is that the total age for the period to weather to the present soils and regolith has to then be placed at between 20,000 years on granite, around 100,000 years on mixed (mainly sediments) geologies to less than 5,000 years on basalts! Clearly, using present day process studies, current land management has changed the rate of evolution of the landscape. The depths of weathering and similar studies on mass balances for soils formed in between basalts on multiple flow "layer cake" terrain also allows assessments to be made of rates of weathering, rates of denudation and thereby, environments of landscape evolution.

The study of stone lines at Sutton, NSW has led to the conclusion that several erosive phases had stripped and shaped the landscape before the areas were covered again by sediment of both aeolian and slope wash origins. The grain size distributions, clay mineralogy and weathering paths all point to a combination of alluvial and colluvial material derived from upslope combined with aeolian material from the west.

The presence of clay minerals that do not form part of a consistent weathering pathway in soils can lead to the recognition of other sources of parent materials. Quartz grains on basaltic parent materials are an oft quoted example but many smectites in soils formed on felsic materials also suggest that other materials have been added to a soil or regolith profile and therefore a period of sedimentation has occurred. In soils studied form the Northern, Central and Southern Tablelands, multi-modal distributions of quartz suggests that at different times climatic (or weather) conditions were such that wind velocity or direction contributed different sized grains. These grains do not appear to have been centres of parna because of the grain shapes.

Ghosts of parna-like aggregates, alongside non fitting mineralogies in some soils suggests that clay aggregates were a source of materials moved on to sites by wind or water. Since these only exist in the uppermost horizons then accession seems to have been recent.

The careful characterisation of soil and regolith features can be used to interpret processes of formation and these can then be used to establish the history of landscape evolution on any particular site. The soils and regolith provide a similar record to that currently read from sedimentary deposits. Once we have developed the skills to interpret the evidence, the information can be included in any landscape analysis.

SLOPE - CHANNEL DECOUPLING IN WOLUMLA CATCHMENT, N.S.W., AUSTRALIA: THE CHANGING NATURE OF SEDIMENT SOURCES FOLLOWING EUROPEAN SETTLEMENT

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Metamorphosis of the lower Bega River, on the far south coast of New South Wales (NSW), at the end of the C19th was aided by highly efficient downstream transfer of materials eroded from tributary catchments in the few decades following European settlement of the region. Extensive volumes of sediment were reworked from valley fill deposits that had accumulated over thousands of years at the base of the escarpment. Within a few decades of European settlement, channel incision transformed these discontinuous river courses throughout Wolumla catchment (a tributary of the Bega River). The development of continuous channels greatly increased sediment delivery from the catchment.

Various studies have documented the transformation of river landscapes following European settlement of southeastern Australia. However, to date, there have been few systematic assessments of the relative timing and volume of materials eroded and transferred from differing sediment sources within these catchments. This paper documents the character, timing and proportion of sediment sourced from upland valley fills, channel expansion sites, and gully networks. Volumes of material transferred from these sources are compared with estimates of sediment eroded from hillslopes.

Of critical concern is the balance between erosion of materials from hillslopes and their transfer to the valley floor. In a decoupled system, where sediment transfer to the valley floor is inefficient, sediments are stored on-slope or in intact lower order drainage lines. In this case, colluvial sediment contributions to the fluvial system are trivial. Alternatively, slope-channel coupling occurs when sediments are supplied directly to the fluvial system, where they are reworked and transported downstream.

Although disturbance of slopes in Wolumla catchment resulted in significant movement of materials, most of this material has been stored on-slope, in trapped tributary fills and along lower order drainage lines. The slopes are effectively decoupled from the channel. Around 75 % of the total volume of material released from creeks in Wolumla catchment since 1865, i.e. 5,500 x 10^3 m^3, has been derived from incision into valley fills. Sediment flushing occurred within a few decades of catchment clearance. Bedrock confinement in the middle and lower catchment resulted in very efficient downstream transfer of materials. Although gully networks and channel expansion sites have released a relatively small volume of materials, these sources are the greatest contemporary source of materials in Wolumla catchment.

APPLICATION OF STREAM POWER ANALYSIS TO MANAGEMENT OF AN INCISED STREAM CHANNEL

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The Lang Lang River, Victoria, Australia, drains a highly modified catchment. The steep headwaters have been cleared almost entirely of tree cover. This, combined with the low porosity soils, and the high intensity storms that the region experiences, means that event discharge in the river can reach a very high magnitude. The river debouches onto a large alluvial fan at Heath Hill. Prior to land clearing and draining this fan would have been lowland swamp for much of the year, with the river cutting a sinuous course to the mouth at Westernport bay. The river would have regularly flooded onto adjoining land. Floodplain draining, and channelisation and diversion of the lower watercourse caused the river to follow a straighter, steeper alignment, but it had to convey higher discharges. The river responded to the imposed changes in alignment and flow regime by incising into the floodplain. The extent of this incision is spectacular, with the upper section now accommodating at least the 1:100 year flood.

Currently the channel shows signs of instability. Geomorphological management concerns are nickpoint progression causing loss of bridges, bank erosion causing loss of the levee bank (and therefore increasing risk of flooding), and transport of sediment to Westernport Bay which could degrade the habitat quality for fish and other organisms.

Stream power analysis revealed that even the 1:1 year event has sufficient power to be erosive over much of the river length from Heath Hill to the junction of Adams Creek. Erosive stream powers occur for discharges above 10 m^3s^{-1} in the section from Heads Road weir to Patullos Road. The sections that experience the highest stream powers also had the most obvious erosion present, in the form of bank erosion and bed degradation. Comparison of bed profile surveys done in 1968, 1972, 1979 and 1996 revealed that the rate of bed elevation change has slowed through time. After it was constructed in 1980, the weir at Heads Road caused massive sediment deposition in the reach immediately upstream. However, degradation was still the dominant process (river length average of 0.01 myr^{-1}), with sections from the Little Lang Lang junction to just below the South Gippsland Highway degrading at up to 0.1 myr^{-1}. The historical changes in bed elevation are consistent with the conclusions drawn from the stream power analysis and field observations. The load of sediment from the incised section of channel is equivalent to about 24% of the total load of suspended solids delivered by the river to Westernport Bay. About 63% of the sediment delivered by the river to the Bay comes from the headwaters of the catchment above Heath Hill.

Installation of grade control structures in the sections of river that have the highest stream power and which show signs of headward erosion will halt erosion in the short term. However, in the long term, the river will continue to adjust to its flow regime. Thus, failure of structures and lateral channel migration should be expected in the future. One way to halt these processes is to regulate the flow, so that highly erosive flows do not pass through the sensitive parts of the channel. This can only be achieved by diversion and temporary off-stream storage (in abandoned stream courses) of the upper parts of high magnitude events. In the long term, management could aim to reduce the percentage of rainfall that contributes to storm event runoff. Reafforestation of the headwaters could be a useful strategy, but removal of floodplain drains would also help.

GEOLOGICAL BACKGROUND TO SOUTH AUSTRALIAN SCENERY

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The ancient crust in South Australia was eroded, deposited, intruded and metamorphosed repeatedly in Archaean, Proterozoic and Cambrian times. From the Ordovician through to the latest Carboniferous, prolonged erosion over 200 million years had removed kilometres of this crust, exposing rocks that had been folded and deeply buried. Thick ice caps then spread from the south, deepening and infilling valleys and several tectonic troughs, spreading far travelled fluvio-glacial debris over the land. Examples of these Permian glacigenic sediments are scattered over Yorke and Fleurieu Peninsulas and Kangaroo Island.

Another 180 million years of crustal stability continued and very high world sealevels during the Cretaceous flooded vast areas of low-lying Australia (Great Artesian Basin). However, a giant rift system then formed along Australia's southern edge where volcanoes erupted, the sea invaded from the west, and the final breakup of Gondwana began. Remnants of this low-relief Cretaceous topography are possibly the oldest surfaces forming the high parts of the Gawler, Flinders, and Mt Lofty Ranges.

It was another seventy million years later, in the Late Eocene, when Australia's rapid northward drift thinned the crust which then subsided, forming the Eucla, St. Vincent, and Murray Basins. This was when a new drainage system eroded into the ancient Gondwanan landscapes and the Mount Lofty Ranges rose up along its eastern side. Subsidence, and deposition of predominantly limestones under fluctuating sea levels, characterise these basins. A 650 km long coastal dune system of latest Eocene to Miocene age, is still preserved along the ancient shores of the Eucla Basin. Subsequent lowering of sea level has exposed the cliff-forming horizontal shallow marine limestones in the Eucla and Murray Basins.

The Late Miocene saw a major tectonic change from crustal tension to compression. As a result, the eastern St -Vincent Basin separated into several parts, tilting the Tertiary layers gently southward. The coastal parts were planated and covered with Pliocene coastal sands and gravels. The western Mt Lofty Ranges began to rise with most rivers now cutting deep gorges. To the southeast, broad and steady uplift has characterised the Mt Gambier region and south western Victoria, from Pliocene to the present. This has preserved a long and continuous record of sealevel oscillations expressed as beach-dune ridges elevated up to 120 m in about 5 million years. The axis of this uplift has included the young basaltic volcanics of Mt Gambier and Mt Schank.

Shoreline deposits as young as 125 ka provide clear evidence of ongoing crustal movements: Eyre Peninsula has remained remarkably stable, St Vincent Gulf is sinking, the Adelaide Hills are rising, and east of the Murray mouth, the crust is rising steadily towards Mt Gambier. We not only live on an ancient continent, we also live in interesting times.

PANS, DOLINES AND OTHER HOLLOWS IN THE GAMBIER KARST PROVINCE, SOUTHERN AUSTRALIA.

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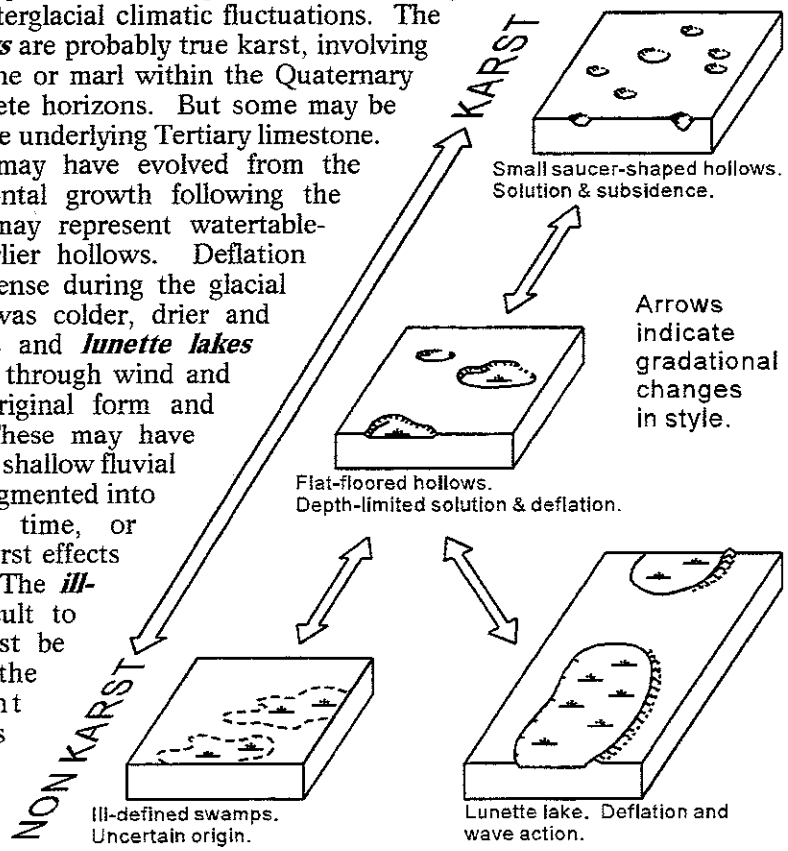
Many typical karst dolines, uvalas and dry valleys occur in the limestone-dominated regions of the Gambier Karst Province, such as the Naracoorte Plateau. However, there are also karst-modified dune hollows, and many shallow hollows of less obvious genesis. The last will be the subject of this paper. They are a feature of the flat, poorly-drained Bool Region, an extensive Pleistocene coastal plain. No significant caves are known beneath the plain, but caves do occur in the calcareous dune ridges that cross it. The deposits of the old coastal plain are mainly marls (calcilutites and dololutites) with local non-calcareous muds, calcareous sands and sandy limestones. These are up to 13m thick and overlie soft Pliocene calcareous quartz sands and then Tertiary Gambier Limestone at depths of 15 to 25 m.

The Shallow Hollows and Their Setting

There are four types of shallow hollow, but all gradations occur between these end-members (See Figure). ***Saucer-shaped hollows*** are the smallest, typically from 1 to 3 m deep and generally less than 100 m across. They occur both on the coastal flats of the Bool Region and on the dune ridges and Tertiary limestone areas. ***Flat-floored, swampy hollows*** are most common in the Bool Region, where they form extensive fields, but examples occur in all the regions. Typically they are less than a metre or two deep and can be from 50 m to more than 500 m across. They may have seasonal lakes. A third type comprises the shallow ***lunette lakes*** that are characteristic of the Bool Region. These are larger variants of the flat-floored swampy hollows, but with smoothly-rounded, sharply-defined margins and a lunette ridge on the eastern side. Fourthly, ***ill-defined shallow swamps*** with irregular outlines may be extreme end-members of the flat-floored swampy type. These are most common in the Bool Region.

Possible Processes Forming Hollows in the Bool Region

Taken as a whole, the hollows in the Bool Region are polygenetic - with solution, deflation and other processes operating in parallel, or in sequence, or alternating in step with the glacial - interglacial climatic fluctuations. The ***small saucer-shaped hollows*** are probably true karst, involving solution of beds of limestone or marl within the Quaternary coastal deposits or of calcrete horizons. But some may be subjacent karst related to the underlying Tertiary limestone. The ***flat-floored swamps*** may have evolved from the smaller saucers by horizontal growth following the sealing of the floor, or may represent watertable-controlled deflation of earlier hollows. Deflation would have been most intense during the glacial stages when the climate was colder, drier and windier. The larger pans and ***lunette lakes*** reached their present form through wind and wave action, but their original form and genesis is less certain. These may have started as coastal hollows or shallow fluvial stream-ways that became segmented into chains of hollows with time, or subjacent karst or direct karst effects may have been involved. The ***ill-defined swamps*** are difficult to categorise - many may just be slight irregularities in the original low-gradient depositional surface; others have linear or dendritic forms that suggest former water courses.



THE VALIDATION OF A PHYSICALLY BASED LANDSCAPE EVOLUTION MODEL USING EXPERIMENTAL, POST MINING AND NATURAL CATCHMENTS

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SIBERIA is a physically based model used to simulate the evolution of landscapes. It links widely accepted hydrology and erosion models under the action of runoff and erosion on the evolving landform over long time scales. A geomorphologic evolution model can be physically tested in three ways by using (1) model landscapes, (2) mine waste or badlands and (3) real landscapes.

Model landscapes are scaled down, simplified versions of field landforms. Model landscapes permit the identification, isolation, manipulation under precisely controlled conditions of processes and variables that are difficult to investigate in the field. An evolving system can be studied. Model landscapes also permit the control and study of various initial and boundary conditions. While it is recognised that model landscapes have limitations in representing real landscape evolution such as, (1) initial and boundary conditions may be very different to those of nature, (2) materials used in the model may bear little resemblance to those in nature and (3) as the model decreases in size there is also the question of the effects of scale they offer the best method of comprehensively verifying a physically based landscape evolution model over a short time frame for a substantial subset of erosion processes that are observed in the field. A series of model experiments to test SIBERIA are discussed.

Mine waste or badlands also offer a good opportunity for geomorphic evaluation. These landscapes offer considerably enhanced erosion, hence, evolution occurs at an increased rate. The difficulty is that initial conditions are impossible to control. In addition, landscape evolution, while considerably faster than in natural landscapes can still take many years to advance. Therefore time in the verification of a model can still be a big factor. Despite these problems, mine spoil offer an opportunity to test SIBERIA over the short and medium term. Testing of SIBERIA at the abandoned Scinto 6 mine is discussed.

Real landscapes offer the most complete and realistic opportunity for testing a physically based landscape evolution model. Their inherent disadvantage is that geomorphic processes take considerable time with a landscape evolving over thousands of years. Clearly we are not on this earth long enough to test a landscape evolution model against a real landscape. However the evolution can be inferred where land management history, past climate, vegetation and erosion characteristics are sufficiently well known to be able to predict current landforms and thus test the model. A catchment, such as that at Tin Camp Creek, Arnhem Land in the Northern Territory offers such an opportunity.

Comparison of experimental, post mining and natural landscapes with SIBERIA simulations using geomorphic statistics such as the hypsometric curve, width function, cumulative area diagram and area-slope relationship demonstrate that SIBERIA can accurately simulate these landscapes.

GEOMORPHOLOGY OF A MICROBIOTIC PLANET

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Microbes may be second only to plate tectonics in their effect upon the physiography of the earth, having affected our climate almost since the planet's earliest days. Owing largely to the effects of microbiota, carbon dioxide (CO^2) levels in soil typically are 10 to 1000 times higher than in the atmosphere, which leads to production of carbonic acid, which promotes weathering and enhances erosion. If soil CO^2 was not so raised, atmospheric CO^2would be very much higher in order to balance the output from volcanoes and metamorphic rocks, and global temperatures could be 15-40°C higher than today, owing to the consequent greenhouse effect. Earth temperatures have not been very different from present for most of geologic time, however. This suggests that "organic" soil inhabited by microbes mantled the land, long before it was colonised by higher plants.

Not only the climate but the shape of the earth's landforms is mediated by production of soil by rock weathering. Computer models of landforms without soil are very different to those with soil, which vary with the rate of soil production. Rates of soil production and what controls these require closer study, to understand landforms better and, perhaps more important, to manage our soil resources, because Australia's soil losses through erosion are unsustainably high and may be up to 100 or more times the rate of natural soil production.

A new method of measuring soil production rates has been applied to field sites near Bega and Cooma, by a group from the University of California, Berkeley, and from RSES at ANU. Soil production is determined from measurements of radioactive nuclei formed in soil and rock minerals by cosmic rays: results show that the thicker the soil, the slower is its rate of formation. This does not mean that natural replenishment will become so rapid as to keep up with soil losses when the soil becomes thin, because the highest rates measured so far under the thinnest soils turn out to be very much slower than agricultural soil losses. Natural soil production rates vary enormously within Australia and between Australia and neighbouring Papua New Guinea, however. The paper examines factors that the rate of soil production, including the effects of accelerated denudation during Pleistocene cold periods.

MOSAICS OF ONGOING DEVELOPMENT IN THE EVOLUTION OF LANDSCAPES (MODEL): A NEW CONCEPTUAL MODEL FOR REGOLITH AND LANDSCAPE EVOLUTION

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One of the challenges for the study of landscape and regolith evolution has been the construction of robust genetic models. Traditionally many of the models have had a strong emphasis on incorporating episodic events often of regional stratigraphic significance. These have manifested themselves in the forms of interpretations and extrapolations of Davisian and Penckian models (such as palaeosurface studies featuring regionally extensive peneplains and pediplains), morphoclimatic models (such as the emphasis of climatic controls on landform development and weathering styles), and the current dominance of a paradigm promoting the long-term landscape stability and antiquity of the Australian landscape.

Recent studies in many parts of Australia, such as western NSW and southeastern South Australia, have found these traditional models to be unsatisfactory in accounting for the evolution of landscapes and associated regolith materials. Instead a model featuring the continual modification of landscapes and regolith materials throughout the history of landscape development appears to provide a more accurate account. Importantly this ongoing regolith and landscape development is operating at variable rates not only over time but also over space, largely in relation to changes in landscape setting and associated environmental conditions. The result is a model featuring Mosaics of Ongoing Development in the Evolution of Landscapes (the MODEL model).

The MODEL model provides a new framework for the interpretation of regolith and landscape evolution. This is illustrated by applications accounting for the history of development and landscape expressions of duricrusts (such as ferricretes, calcretes and silcretes), weathering profiles, morphotectoism, sedimentation and erosion.

REGOLITH GEOLOGY AND LANDSCAPE EVOLUTION OF THE SOUTHERN BROKEN HILL BLOCK, WESTERN NEW SOUTH WALES

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To most Earth scientists the Broken Hill region is famous for its bedrock geology and associated mineralisation. However, the regolith geology and long-term landscape history are also integral parts of Earth Science research in the region. Regolith geology and landscape evolution are also important components of the region's Earth science features, enabling interpretations of the later geological history and palaeo-environmental development of the region. This has implications for regional mineral exploration and land management practices.

The approach to studying the regolith geology and landscape evolution in this region initially involved regional regolith-landform mapping at 1:500,000 and 1:100,000 scales. This has provided both regional coverage and context for more detailed studies. Regional regolith sampling and characterisation was then conducted as a part of the 1:100,000 mapping and along the AGSO seismic transects. Detailed mapping and regolith characterisation of selected areas at 1:25,000 scale are now underway. The main emphasis of this mapping is on the Balaclava and Redan 1:25,000 mapsheets to the south of Broken Hill. These areas include active mineral exploration tenements, although previous exploration approaches have largely focussed on bedrock sampling media. These regions, however, mostly feature regolith-dominated terrain particularly south of the regional transition from the bedrock-dominated areas of the central Broken Hill Block. Sedimentation is closely related to the depositional history of the Cainozoic Murray Basin and perhaps even to the older Berri Basin which is a southern extension of the Mesozoic Eromanga Basin. Airborne gamma-ray spectrometry (provided by AGSO), Landsat TM and detailed aerial photography have proven to be valuable aids for regolith-landform discrimination during detailed mapping, and have been combined with digital elevation models, and other data sets.

Regolith stratigraphy and characterisation have then been established throughout this region, utilising samples and profiles obtained from surface sampling, exploration pits, company drilling, and the AGSO seismic lines. Detailed laboratory analyses of the major regolith types have been used to assess their origins, palaeo-environmental and exploration significance. Detailed studies of regolith carbonate accumulations (including calcretes), silcretes, ferricretes and gypcretes reveal their potential importance as mineral exploration sampling media. The landscape and palaeo-environmental setting of these sampling media are a necessary consideration to fully account for chemical and physical dispersion pathways that have existed over the course of the landscape history. These are reflected in the mapped distribution and setting of the particular regolith materials, as well as their mineralogy, chemistry and morphology.

BIO-MIXING COMPARED TO MOUNDING: SOME GEOMORPHIC AND PEDOLOGIC IMPLICATIONS.

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Bioturbation consists of mounding and mixing by various soil animals (and treefall). A reasonable data base exists on mounding rates i.e. the amount of soil deposited at the surface (Paton *et al., 1995*). In comparison there is a dearth of information on bio-mixing, i.e. the rate at which soil is move about below the surface, even though mixing depth functions are often assumed to explain a variety of phenomenon such as the vertical distribution of organic matter and radionuclides.

This paper reports on the results of a 16.8 y field experiment near Sydney which establishes, for the first time, a measured rather than inferred bio-mixing depth function. Mixing was assessed from a column of dyed soil set into a texture contrast soil in a natural woodland setting. The column shows the proportion of dyed soil remaining (= non-bioturbated soil). The net rate of mixing amounts to about 127 t ha^{-1} y^{-1} which is about 21-25 times the rate of mounding at the same site. Preliminary results indicate that earthworms (*Nothoscolex*) and ants (*Aphaenogaster longiceps* and *Camponotus intrepidus*) are the main mixers in contrast to ant dominated mounding.

The study also shows that the rate of mixing declines with depth with an apparent break between existing pedogenic A1 and A2 (E) layers and minor mixing at the top of a saprolitic B. Hence, even with high rates of mixing homogenization does not necessarily follow. The high rate of mixing also makes it difficult to accommodate other soil transporting mechanisms such as soil creep and clay illuviation unless some positive feedback coupling mechanism can be established.

Paton T.R., Humphreys, G.S. and Mitchell, P.B. 1995 Soils: a new global view UCLP

RESURRECTING THE DEAD: CAN FLUVIAL GEOMORPHOLOGY WORK MIRACLES IN REHABILITATING AUSTRALIAN STREAMS?

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For over a century, Australian streams have been modified for flood mitigation and erosion control, and landuse changes have altered flow from their catchments. Today, many stream managers are attempting to reverse many of the human impacts on our streams. The geomorphology of the streams (including cross-section form and sediment flux) provides the fundamental structure upon which the other elements of recovery depend. The goal is often to return some of the original diversity of vegetation and geomorphology, which will in turn, assist in the recovery of the diversity of organisms in the streams. Many millions of dollars will be spent on this endeavour over the next few decades, and fluvial geomorphologists will be in demand to join the multi-disciplinary teams that are rehabilitating streams.

The questions that are being asked of these geomorphologist will often involve knowledge of 'disturbance response functions' for a specific stream.

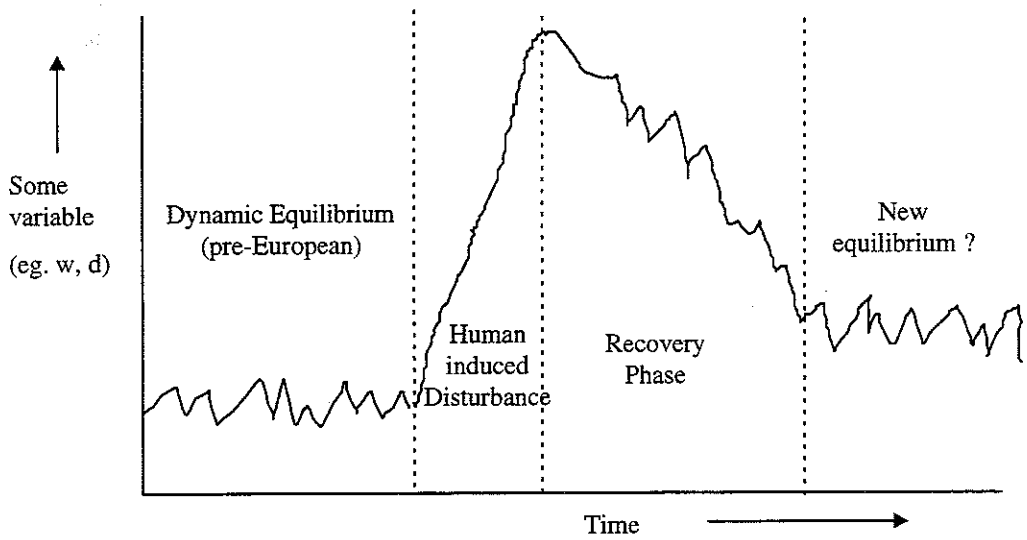

Figure 1: Hypothetical geomorphic recovery path-way following disturbance of a stream system

Geomorphologists are expected to know the original state of the stream (and if it was, in fact, in some dynamic-equilibrium state). They need to know what has caused the disturbance (to see if the pulse or press disturbance is still operating), and they need to know how long the stream will take to return to some new quasi-equilibrium state, and what that state will look like.

How well equipped are we to answer these questions in Australia? It is fair to say that the demands of rehabilitating streams is taxing our knowledge of the geomorphology of Australian streams. This is because it is forcing us to predict rather than just describe. In the process we are forced into challengingly close contact with engineers, and we are beginning to explore the fruitful overlap of geomorphology with hydrology, biology, and ecology. It is often in these overlap areas that fundamental advances are being made.

This paper describes some of the key gaps in our knowledge that we must fill in order to face the exciting new challenge of rehabilitating our damaged streams. It is our contention that the demands of stream rehabilitation will reinvigorate the discipline of fluvial geomorphology.

NEOTECTONICS OF WESTERN VICTORIA AND ADJACENT SOUTHEASTERN SOUTH AUSTRALIA

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Recent regolith studies in Victoria by the Geological Survey of Victoria, the University of Melbourne, and the Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME) have concentrated on the West Victorian Uplands around Ballarat and to the west. In this area, adjacent to the Murray Basin, neotectonics has played a major part in determining landform development and the distribution of regolith, e.g. the 120 m domal uplift affecting late Tertiary shoreline ridges on the Dundas Tablelands (Honours report by Natalie Quinn, 1997). Similarly the lateritically-weathered and uplifted Chatsworth Block south of the Grampians Range has a surface showing Tertiary shoreline ridges.

The deposition of the shoreline ridges of Parilla Sand (with their mineral sand resources) in Victoria, and of the Quaternary limestone ridges of SE South Australia, e.g. around the Nangwarry area in SE South Australia, was controlled by a landscape which was in part due to young and in some cases contemporaneous tectonics. In South Australia the Padthaway Fault may be related to the uplift of the Dundas Tablelands area in Victoria.

Faulting appears to be related to late Tertiary-Quaternary volcanism around McIntyre-Mt Burr, northwest of Mt Gambier, and uplift has also occurred around Mt Gambier, dated as Australia's youngest volcanic eruption.

Movements related to the Newer Volcanic activity in Western Victoria include uplift of the Mt Clay block northwest of Portland, identified many years ago by Boutakoff. On a similarly-uplifted block of Tertiary limestone, sinkholes have developed by accelerated solution around the Staughtons Hill volcanic complex near Camperdown. The Rowsley Fault scarp west of Melbourne has both faulted and monoclined Newer Volcanic lava flows.

Neotectonic activity appears to be continuing today. In Victoria evidence of faulting within the Murray Basin is known from several areas (e.g. the Cadell Fault at Echuca, the Tatura fault near Shepparton, and a recently-discovered fault on the Campaspe River near Elmore.)

Many new examples of neotectonics are being discovered, and the new AUSLIG Digital Elevation Model may help provide further examples.

The implications of neotectonics for the continuing development of the Victorian Highlands, for local erosion (Dundas Tablelands), for drainage changes (annular course of the Glenelg River following capture of a north-flowing palaeoriver in the Douglas Depression of the Wimmera), for groundwater movement on and around domes and along faults (Elmore), and the association with volcanic activity are of interest for future study, as is the association of areas of neotectonics with modern earthquake activity.

GRANITE LANDSCAPES OF SOUTHEASTERN AUSTRALIA: FACTORS INFLUENCING ELEVATION, RELIEF, OUTCROP AND WEATHERING

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Granitic intrusions are a major feature of the Palaeozoic geology of the Lachlan Fold Belt (LFB), and are exposed over more than 20% of the landscape of southeastern Australia. Granite landscapes range from high-level **plateaus** with extensive outcrop, such as Mt Buffalo and Mt Baw Baw, through areas of intermediate elevation with outcrop on **hills and ridges** alternating with soil and alluvial-surfaced basins, such as the Harcourt and Cobaw batholiths, to **lowland plains** with a deep alluvial cover and little or no outcrop, such as Amphitheatre and the Murmungee Basin; in the last examples metamorphic aureole ridges are often the main indication of a granitic body being present.

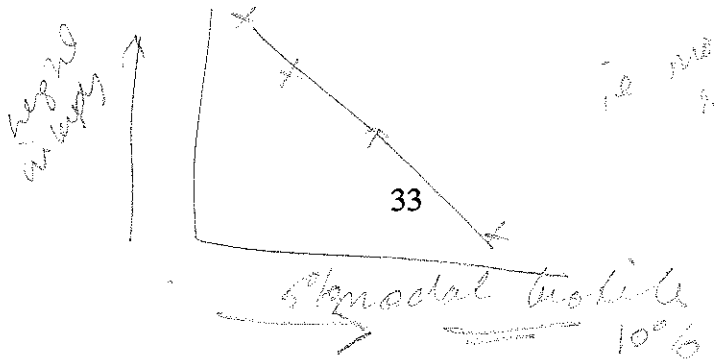
Granitic landscapes may also be classified according to the type of tor landscape developed e.g. **large, widely-jointed tors** and well-developed half-domes, often of relatively fresh rock, contrasting with **small and often irregular tors and corestones**, often partly weathered.

Factors which may influence the form of the granite landscape can be summarised as:

* felsic and mafic granites; felsic granites generally form high landscape features, and mafic granites with a higher content of biotite and hornblende often form low areas (Hill 1996).
* grain size of the granite, especially of the feldspars - large grain size favours the development of coarse jointing and large tors.
* oxidised and reduced granites i.e. variations in oxygen fugacity (fO_2) - landscape effects may vary.
* high and low magnetic signature, as best seen on recent airborne geophysical imagery, and related to magnetite content; may show no obvious correlation with elevation of the area.
* I- and S-type of Chappell & White (1992); S-type are generally higher in quartz, even when mafic, and so may form high landscape features.
* multiple, zoned, sometimes concentrically-ringed intrusions of varying composition and grain-size are common; fortunately such zoning may sometimes be recognised and mapped by the regolith signatures seen on airborne radiometric imagery.
* Near surface ("subvolcanic") intrusions e.g. Ararat-Stawell area, are most common in the LFB, and are moderately felsic, with close vertical jointing, and form high landscape features on exposure, while the less-common deeper level ("contact aureole") intrusions often instead form low features when exposed, but may sometimes be found high in the landscape e.g. Mt Cole.
* age of granites - LFB granites range from 420-390 Ma, down to 360 Ma near Melbourne, and are thus mostly Devonian in age, with some Carboniferous granites to the east and Silurian age granites in the west.

The factors influencing granite weathering may be readily studied in Victoria, where many examples have been mapped and chemically described, and where recent airborne geophysics by the VIMP initiative of the Geological Survey of Victoria provides detailed magnetic and radiometric imagery which is being used in a program of geological and regolith landscape mapping. The most important conclusion to date seems to be that felsic granites form high landscape features, and mafic granites (high in biotite) form low areas.

The development of landscapes on granite has particular implications for the preservation of high-level palaeosurfaces (e.g. the Baw Baw or Mesozoic palaeosurface in Victoria) which are currently attracting interest as perhaps the oldest surviving features of the local landscape and a key to understanding the early landscape evolution of the Highlands. The use of fission track dating may help in understanding the unroofing of granites as the initial stage of their evolution into the landforms of today's landscapes.



MORPHOLOGY OF A VERY QUIET RIVER, THE LACHLAN DOWNSTREAM OF COWRA, NEW SOUTH WALES

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The Lachlan River in central western New South Wales belongs to that group of Riverine Plain channels generally described as sinuous, stable, low-gradient, suspended load streams, which have made little geomorphic impact on their floodplains in the last 10,000 years. They flow between high mud banks of great stability, slightly leveed and densely lined with River Red Gums. Extremely low rates of lateral migration by point bar deposition and counterpoint sedimentation have resulted in a narrow floodplain, often confined to a small bench beside the river and bounded by more extensive Pleistocene alluvium. Meander cutoffs are reasonably rare events. Between Cowra and Forbes, the floodplain is confined by up to four terraces. The lowest terrace exhibits ridge-and-swale topography within large Pleistocene meanders, into which the modern Lachlan is entrenched and which is the dominant control on the course of the present river. In some places, a tri-modal meander pattern reveals a previous, underfit regime operated, probably during the early Holocene. The result is an extremely complex and tortuous course which promotes occasional avulsions in its downstream reaches.

Despite its complex history, not all of the features on the floodplain and low terraces can be ascribed to inherited fluvial forms. Deep chute channels have been cut into former scroll plains, swirl pits are a common feature around the larger river gums, large floodplain scours and scoured back channels can be found in confined reaches. At the same time, the channel itself shows no evidence of widening in response to larger flood flows. Floodplains where channel widening cannot easily occur may display features normally associated with deep, high velocity flood events.

HOLOCENE LAGOONAL INFILL AT THE LATITUDINAL LIMITS OF REEF GROWTH, LORD HOWE ISLAND, TASMAN SEA

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Lord Howe Island (33°30'S, 159°05'E), in the Tasman Sea, appears to mark the southern limit of coral reef growth in the Pacific. Coral growth is locally abundant in the shallow water environments around the island, but there is only one major reef which occurs on the western side. This reef is 6 km long and encloses a shallow lagoon, generally less than 2 m deep, and up to 1 km wide.

The reef is dissected by three main passages which allow the propagation of deep water wave energy into the lagoon. The lagoon floor is therefore subjected to reworking with a mobile surface sand zone dominating. Lagoonal coral growth is concentrated within the back-reef and a lagoonal coral zone, the latter is locally characterised by large circular shaped structures and two small patch reefs. The sedimentology of the lagoon floor is dominated by coarse carbonate sand and gravel. The dominant component of the surface sand is red algae, the composition of which does not appear related to surface zonation.

Seismic and vibrocoring investigations indicate that the Holocene sediment thickness varies between 5 and 20 m. These sediments are dominated by a bimodal mix of coral gravel and fine micritic mud, which underlies the surface sand. There is no modern analogue of these sediments. Sedimentation in the lagoon was initiated around 6.5 ka as an *in situ* branching coral gravel. The bulk of the lagoonal gravelly mud was deposited between 6 and 4.5 ka. The southern (deeper) half of the lagoon appears to have lagged behind the northern part by 1000 years. Sedimentation after 3 ka is dominated by coarse sand. Deposition since the mid-Holocene has been concentrated within the coastal, protected embayments and 'holes' in the lagoon.

GEOMORPHOLOGY OF HEARD ISLAND

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Subantarctic Heard Island is dominated by the heavily glacierised Big Ben strato-volcano, which attains 2745 m altitude and is the highest mountain on Australian territory outside Antarctica. The volcanic landforms of the island also include a caldera on Big Ben, scoria cones, domes, open vertical volcanic conduits and lava flows that exhibit inflation landforms and lava tubes. There is ongoing volcanic activity from the summit of Big Ben, while Australia's second active volcano was discovered on nearby McDonald Island in March 1997.

There is close interaction between volcanic, glacial and coastal processes and landforms on Heard Island. The development of glaciers on Big Ben has been partly a response to progressive growth of the volcano itself over the last ~1 Ma. The earliest glacial sediments may occur within the Late Miocene - Early Pliocene Drygalskii Formation which forms a 300 m high plateau along the northern coast of Heard Island, but further research is required to confirm this. Debris avalanching has sculpted large hollows into some flanks of Big Ben, particularly along its southern side, providing topography favourable to vigorous and erosionally effective glacier flow. However, many glaciers still reach sea level and few well developed landforms produced by glacial erosion are exposed on this very young mountain. Smaller hollows in the surface of some glaciers may reflect a subglacial equivalent of the amphitheatre-headed valleys that develop on fluvially dissected volcanoes. Active ice surface moraines are abundant but there are few areas where older moraines have been able to accumulate on land. None of these moraines seem likely to be much older than Middle Holocene.

The sea floor 2-4 km off the south coast is markedly shallower than elsewhere around Heard Island, presumably reflecting some combination of bedrock topography, debris avalanche sediment and glacigenic sediment. Vigorous longshore drift and an abundant sediment supply have produced a large spit at the downdrift end of the island, forming bars from reworked glacigenic sediment that now impound proglacial estuarine lagoons, and has allowed rapid progradation along parts of the coast over recent decades. Conversely, marked coastal recession has occured downdrift of some glaciers that formerly extended into the sea but which have retreated inland over recent decades. Progressive wasting of stagnant ice forward of the active snouts of some of these glaciers has allowed rapid enlargement of their proglacial lagoons.

Glaciological studies have proven the glaciers of Heard Island to be sensitive indicators of short term climatic changes over historical time, and studies of the glacial and coastal sequences should allow this record to be extended back further into the geological past. For a reliable climatic record to be obtained the history of volcanic activity must also be determined so that its effects on the glacial and coastal landforms and sediments can be discriminated from those of climatic forcing.

OPTICAL DATING STUDIES OF LOESS AND FLUVIAL SILT FROM OKARITO FOREST, WEST COAST OF SOUTH ISLAND, NEW ZEALAND

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Over the past decade there has been an increasing amount of research directed toward the understanding of the geomorphic history of western South Island (Westland). Although radiocarbon analysis of organic material has been a valuable dating tool, there are key deposits, representing significant geo-climatic events, that are too old for radiocarbon dating.

Recently a thick (~1.3 m) deposit of peat was exposed in Okarito Forest (the Okarito pit site). This peat is overlain by 3 m of glaciofluvial silt, sand and gravel, and is capped by 1 m of peaty soil. It rests on glacio(?)fluvial silt and gravel. Preliminary pollen analysis suggests peat accumulation during $\delta^{18}O$ stage 3 (ca 65- 30 ka) although this could not be confirmed by radiocarbon dating. Radiocarbon analysis by accelerator mass spectrometry of the surface 10 cm increment of the peat and wood from the middle of the deposit yielded limiting ages of >47 ka BP. To substantiate that deposition did indeed occur during the early part of $\delta^{18}O$ stage 3 an alternative dating tool was needed.

Optical dating of common minerals such as quarts and felspars can be used, under the right circumstances, to date when sediment was last exposed to sunlight. The accepted upper limit of this method is presently ~150 ka. The reliability of any optical age, however, depends not only on understanding the depositional environment, but also on knowledge of the minerals present and how they behave during laboratory analysis.

In the Okarito pit, deposits most suitable for optical dating are fine-grained loess and floodplain silt. Infrared excitation of potassium felspars is therefore the most suitable optical dating method. Early results from floodplain silts bounding the peat suggest, however, that the ages obtained may be too young by 10-20%. The reason for this may lie in the mineralogy of the samples.

In this paper we present optical ages from the Okarito pit and describe the laboratory procedures necessary to ensure that the ages are credible. The utility of the technique for dating sedimentary events in the wider study area is discussed.

RESULTS FROM RECENT AEOLIAN PROCESS STUDIES IN THE EASTERN SOUTHERN ALPS, NEW ZEALAND

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Contemporary aeolian processes in the eastern Southern Alps, New Zealand are mostly confined to the dry braided river channels of glaciofluvial meltstreams, exposed lacustrine deposits and the degraded tussock grasslands of inner montane basins. The most favourable conditions for the entrainment of fine grained sediments by the wind in these environs have been monitored during foehn wind storms, when wind speeds exceed the threshold entrainment velocity of approximately 7.5 ms^{-1} in the absence of precipitation. Frequently, wind speeds during such events exceed 25 ms^{-1} with maxima of 40 to 50 ms^{-1} monitored during severe foehn wind storms. Saltation clouds sampled at 0.5 and 1 m above glaciofluvial deposits during these events have been found to display mean grain sizes of between 300 and 435 μm, while grains larger than 1000 μm have been collected in samplers 2 m above the surface (McGowan 1997, McGowan and Sturman 1997). These large grains which saltate downwind over the cobble and pebble sized clasts associated with the meltwater river systems of the eastern Southern Alps are thought to be the principle agents in dust storm genesis, as they effectively erode and release finer grained silts from dry exposed overbank and lacustrine deposits through ballistic impact processes. Computer image analysis of silt sized grains filtered from the airstream identified more rounded grains to be carried higher into the airstream soon after entrainment. As a result, they are preferentially carried into zones of higher wind speed and are therefore transported further downwind before being deposited. This process is thought to account for the often observed increase in grain roundness of loess deposits with increasing distance from the source area, as reported by Mazzullo et al. (1992).

While, the eastern Southern Alps act as the principle source of contemporary aeolian sediments and aerosols which affect the eastern South Island, deposition of aeolian sediments which have been transported thousands of kilometres, mostly from Australian sources are also reported in this region. McTainsh (1989) summarised numerous reports of *red snow* and *red rain* events in the Southern Alps, and elsewhere in New Zealand. The deposition of Australian dust is often associated with the same general synoptic weather patterns that initiate foehn conditions in the eastern Southern Alps. However, over the western slopes of this mountain barrier such weather patterns typically result in orographic precipitation which effectively scavenges the suspended dust particles from the airstream. Recently, a kinematic trajectory model has been used to recreate the trajectory paths of dust contaminated air parcels that originated from South Australia. Results highlight the diversity of trans-Tasman dust transport paths and provide the opportunity to identify the origin of *red dust* deposited in the Southern Alps through backward trajectory analysis. As a result, a research programme is currently planned to collect snow samples from a site near Mt. Cook for analysis during the 1998/99 snow season. Backward trajectory analysis will be used to identify the origin of any *red dust* found in the snowpack.

In summary, the eastern Southern Alps provide a unique natural laboratory in which to examine aeolian processes in a highly dynamic and high energy alpine setting. Research from such locations has not often been reported in the literature on aeolian processes which is still largely dominated by articles reporting on studies conducted in sub-tropical desert and beach environs. However, results from recent studies completed in the eastern Southern Alps are providing new information on meteorological controls on wind erosion, loess genesis and long range dust transport processes.

References

Mazzullo, J., Alexander, A., Tieh, T. and Menglin, D. 1992. The effects of wind transport on the shapes of quartz grains. *Journal of Sedimentary Petrology*, **62**, pp961-971.

McGowan, H. A. 1997: Meteorological controls on wind erosion during foehn wind events in the eastern Southern Alps, New Zealand. *Canadian Journal of Earth Sciences*, **34**, pp1477- 1485.

McGowan, H. A. and Sturman, A. P. 1997: Characteristics of aeolian grain transport over a fluvio-glacial lacustrine braid delta, Lake Tekapo, New Zealand. *Earth Surface Processes and Landforms*, **22**, pp773-784.

McTainsh, G.H. 1989: Quaternary aeolian dust processes and sediments in the Australian region. *Quaternary Science Reviews*, **8**, pp235-253.

THE MOTHER'S DAY OF ALL STORMS: EFFECTS ON THE NSW SOUTH COAST ESTUARIES

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A major storm event between 8th and 13th May 1997 produced significant wave and storm surge effects along much of the NSW coastline. The NSW ocean tide gauge network and the Waverider buoys deployed along the coast recorded the event (MHL, 1997).

The records reveal that the wave heights recorded at the peak of the storm were the largest recorded along the NSW central coast since the major storms of May and June 1974. In fact, while the wave heights were lower along the north and south coast regions, the Hmax storm waves recorded by the Sydney and Port Kembla wave recorders (13.8 metres) rank as the highest on record.

The storm surge ranged from 0.55m along the north coast to 0.2m along the south coast with the peak surge recorded in Port Stephens (0.68m) on 11th May 1997. Storm surge was, therefore, more significant on the north coast while wave heights were more important over the central coast of NSW.

While damage to coastal structures and beaches was not as severe as for the 1974 storms, there were substantial erosional effects recorded, especially along the central and north coastal areas. In the central to mid-south coast region washover effects at the entrance to estuaries provided a noticeable change to pre-existing entrance conditions. The relative effects at each estuary depended on a range of variables including orientation, existing entrance condition and scale and position of washover deposits. Water level records for a range of estuary types have been examined to document the effects of the storm deposits on the tidal and long wave regimes for the estuaries. Implications for estuarine circulation are discussed in the presentation.

Estuaries with a permanently open entrance (eg. Tomaga River) were able to absorb the storm effects with either, little change to tidal flux or a relatively short recovery period. Intermittently opening estuaries responded differently according to the state of the estuary entrance immediately prior to the storm. Lake Conjola, which was closed, exhibited a sharp increase in water level, largely due to overwash by marine water, while Burrill Lake saw significant restriction through overwash deposits which severely choked the ensuing tidal flows and raised the estuary water level for an extended period of time.

The ability of an estuary to absorb or recover from morphologic changes produced by major storm events depends both on the nature of the storm and the preceding morphologic state. The May 1997 storm on the NSW coast has provided a record which will be valuable in the future management approaches to coastal hazard assessment and entrance management policies.

Reference:

Manly Hydraulics Laboratory: "New South Wales Coast May 1997 Storm Analysis", Report No. MHL886, December, 1997, NSW Department of Public Works and Services, Manly Hydraulics Laboratory.

BEACH CUSP MORPHOLOGY AND SWASH CIRCULATION

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Beach cusps are morphological features found on the beachface, consisting of steep-gradient, seaward-pointing cusp horns, and gentle-gradient embayments. They are formed by swash action and usually develop under accretionary wave conditions. Beach cusps often display a marked alongshore rhythmicity, referred to as cusp spacing. It is well established that beach cusps develop and are maintained by a three-dimensional swash flow circulation pattern characterised by wave uprush being deflected from the horns into the adjacent embayments. This swash circulation pattern is referred to as horn-divergent flow and promotes onshore sediment transport and steep gradients on the cusp horns, and offshore transport and gentle gradients in the embayments. The mechanism of initial formation of beach cusp morphology, however, remains an enigma, and at present two explanations for beach cusp formation exist: (1) standing edge waves; and (2) self-organisation.

There are several avenues of investigation available to investigate the two mechanisms of beach cusp formation. The present paper combines previous work conducted by the author and discusses three methods: (1) numerical modelling of three-dimensional swash circulation; (2) investigation of detailed field data on the morphology and water motion during beach cusp formation; and (3) examination of the alongshore variation in beach cusp morphology within a coastal embayment.

The field measurements and numerical modelling indicate the presence of a strong link between swash flow and beach cusp morphology that may explain the maintenance and accentuation of beach cusp morphology, but can not account for the initial formation of beach cusps. Examination of the alongshore variation in beach cusp characteristics on an embayed beach, however, provides strong support for the self-organisation model of beach cusp formation.

GEOMORPHOLOGICAL IMPLICATIONS OF THE OCCURRENCE OF THE ARCOID BIVALVE *ANADARA TRAPEZIA* (DESHAYES, 1839) IN THE AUSTRALASIAN LATER QUATERNARY

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The arcoid bivalve *Anadara trapezia* (Deshayes, 1839) is a eurythermal estuarine mollusc that presently flourishes in eastern Australia between Port Phillip Bay, Victoria and Townsville in northern Queensland. *A. trapezia* first appeared in the Australian Quaternary fossil record during Oxygen Isotope Stage 7. In New Zealand, where it is now extinct, the earliest known occurrences are in the Rangitawa "fossil beds" and in uppermost Castlecliffian strata west of the Wanganui River, North Island (Oxygen Isotope Stage 11, ca. 400 ka). The species had an extensive distribution during the last interglacial maximum (Oxygen Isotope Substage 5e) in both Australia and New Zealand and appears to have had a slightly wider than present geographic range in southeastern Australia during the Middle Holocene, as shown by records from Tasmania and western Victoria, where it no longer lives. Apart from an isolated population inhabiting Oyster Harbour, Western Australia, *A. trapezia* has not been confirmed living in coastal waters west of Port Phillip Bay, Victoria. It became extinct in New Zealand sometime after Oxygen Isotope Substage 5e. The arrival of *A. trapezia* in Australasian coastal waters appears to have been a consequence of planktonic dispersal from southern South America. *A. bravardi* del Rio, from the Middle Miocene Puerto Madryn Formation, on the Valdes Peninsula, Argentina, is believed to have been the direct, linear ancestor of *A. trapezia*.

The distribution of *A. trapezia* in space and time has significant geomorphological implications, not only for Quaternary coastal events, but also for processes in terrestrial environments. In Australia, the extensive distribution and abundance of *A. trapezia* and other fauna of subtropical affinity during the last interglacial maximum, in areas, where both are now extinct, appears to be associated with an enhanced Leeuwin Current at that time, coinciding with higher, less seasonally concentrated levels of precipitation and river discharge. Collectively, the palaeontological evidence points to Oxygen Isotope Substage 5e being generally wetter than the present, Holocene interglacial and may relate to increasing aridity at a continental scale during the later Quaternary. The distribution of fossil *A. trapezia* also provides information about the preservation potential in the stratigraphic record of older estuarine successions. The occurrence of *A. trapezia* of penultimate interglacial age (Oxygen Isotope Stage 7) from the Hunter Valley, New South Wales indicates that older Pleistocene estuarine facies are not necessarily removed during glacial lowstand events.

Deshayes, G.P. (1839). Nouvelles espèces de mollusques, provenant des côtes de la Californie, du Mexique, du Kamtschatka et de la Novelle-Zélande. *In*, M.F.-E. Guérin-Méneville (ed.). *Revue Zoologique par la Société Cuvierienne* **2**: 261-356

LATE PALEOZOIC TO CAINOZOIC LANDSCAPE EVOLUTION OF THE NORTH PARKES MINE AREA, NEW SOUTH WALES: CONSTRAINTS FROM FISSION TRACK AND PALEOMAGNETIC DATA

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We report the first results of an apatite fission track (AFT) study designed to constrain the Late Palaeozoic to Cainozoic thermal and tectonic history of the North Parkes Mine, region, NSW. These results, when combined with recent paleomagnetic results from open pits at the mine, establish a chronological framework, which constrains the landscape evolution of the region. The North Parkes Mine orebody is characterised by a porphyry copper-gold deposit related to Late Ordovician quartz monzonite intrusions. The orebody is overlain by up to 30 m of *in situ* weathered regolith (saprolite) and up to 25 m of weathered sediment-fill deposits of unknown age. Palaeomagnetic analyses were completed on 85 oriented samples collected from both the weathered saprolite and the overlying sediment-fill deposits, exposed within the open pits. Apatite fission track (AFT) analyses have been carried out on seven samples provided by the mine from drill core to 1000 m depth within the monzonite intrusion, as well as from ~15 surface samples collected regionally.

The results of the paleomagnetic analyses suggest that significant periods of weathering of the saprolite and sediment-fill deposits within the mine occurred during the Early to Middle Carboniferous and at some time during the Cainozoic. The fission track results indicate significant episodes of cooling during the Late Permian to Early Triassic and during the Early Cainozoic, presumably in response to denudation. There is no evidence from the present data set to constrains the landscape evolution of the North Parkes region prior to the Early to Middle Carboniferous. However, the inferred Early to Middle Carboniferous period of weathering requires that the ore-bearing monzonite be was close to or at the surface at that time. This could have occurred following a long period of relative stability leading up to and through the Middle Carboniferous, during which time the saprolite formed. Alternatively, the monzonite might have been exposed and weathered following denudation during the Early Carboniferous Kanimblan Orogeny (~350-325 Ma).

The region must may have then been buried under a Late Carboniferous to Late Permian sedimentary sequence, resulting in the resetting of all existing AFT ages to temperatures $\geq$110°C. Subsequently, during the Late Permian to Early Triassic, it is likely that the majority of this overburden was stripped off in response to an episode of rapid cooling/denudation recorded by the AFT data, which may be related to the Hunter-Bowen Orogeny (230 to 255 Ma). From the Early Triassic to the Early Cainozoic, the AFT results suggest that the region was relatively stable with no major episodes of cooling or heating recorded. Then, during the Early Cainozoic, at some time between ~60-30 Ma, a second major episode of cooling/denudation occurred. This resulted in the removal of up to 1000 m of section, and possibly resulted in the formation of the unconformity on top of the weathered saprolite. Subsequent deposition Deposition and weathering of the sediment-fill deposits has then subsequently occurred more recently.

Acknowledgement: We are grateful to Roger Jones of North Limited for arranging the supply of drill core samples from the North Parkes mine for AFT analysis.

FLOODPLAIN FORMATION BY OBLIQUE ACCRETION, MURRUMBIDGEE RIVER

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Floodplain formation on meandering rivers is the result of deposition within the channel margins [point bars, concave benches] and on the floodplain proper [levees, backswamps, crevasse splays and meander cutoffs]. The sediments laid down at bends in the wake of channel migration are known as lateral deposits. Those deposited on the floodplain are known as vertical or overbank deposits. In combination the two result in fining-upward of the meandering floodplain sediment column (Allen, 1970) with vertical deposits overlying generally coarser lateral deposits.

A problem for this model is the reported failure of floodplains to aggrade vertically beyond the level of relatively frequent flooding as indicated by a return period of about 1.5 to 2 years on the annual series (Wolman and Leopold, 1957; Williams, 1978). Among the factors considered to be responsible for the so-called constant frequency of bankfull discharge are the progressive removal of the floodplain by lateral channel migration and the low concentration of suspended sediment in overbank flows. In a study of the Beatton River, Nanson (1977) noted that overbank deposition was significant only on surfaces less than 250 years old.

On the Murrumbidgee River near Wagga Wagga a Holocene scroll-patterned floodplain is underlain by 6 to 8 metres of alluvium which in turn rests on Late Quaternary gravels (Page et al., 1996). Median grain diameters in this unit are in the sand and silt range but show only very weak fining-upwards. It is not obvious whether this material is the result of lateral or vertical accretion. Under the present flow regime the floodplain surface conforms closely to the level attained by the mean annual flood ($Q_{2.3}$) but this probably equates with the most probable annual flood ($Q_{1.6}$) of the pre-reservoir construction regime (Page, 1988).

Recent detailed surveys of the floodplain at six bends have shown that, near the channel, the fine-grained upper floodplain sequence is dominated by oblique accretion deposits (Nanson and Croke, 1992). Similar deposits have been observed in the Darling River floodplain by Woodyer et al. (1977). Oblique accretion layers sometimes form a continuous sequence with point bar deposits but often they occupy the entire river bank above the level of base flow. Our preliminary field data suggest that oblique accretion is confined to the proximal zone of the floodplain and that little deposition occurs on the distal floodplain. This is consistent with the preservation of scroll topography and the failure of the floodplain to increase in elevation (with age) away from the active channel margin.

The stratigraphy of oblique accretion layers reveals alternating layers of fine sand and silt in what appear to be fining upwards flood cycles to 150 mm in thickness. The individual layers decrease in thickness with elevation and generally peter out within 20 metres of the top of the river bank. At aggrading banks these deposits show minimal disturbance by pedogenesis and bioturbation. However, they are not well preserved in the distal floodplain.

Because oblique accretion layers occur almost entirely within the confines of the channel these deposits should be regarded as part of the lateral migration sequence. Thus, a good case can be made on the Murrumbidgee River near Wagga Wagga for floodplain formation almost exclusively by lateral accretion.

MID PLEISTOCENE ARID SHIFT IN SOUTHERN AUSTRALIA AND NEW ZEALAND, DATED BY MAGNETOSTRATIGRAPHY

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In coastal sections at Hallett Cove and Sellicks Beach, south of Adelaide, and at the Red Cliffs section on Kangaroo Island, the Brunhes/Matuyama polarity transition (0.78 Ma) is identified in the strongly oxide-mottled Ochre Cove Formation (Pillans & Bourman 1996, *AGSO Jnl. Aust. Geol. Geophys. 16*, 289-294). At all three sections, the Ochre Cove Formation is overlain by a calcareous grey-green aeolian clay, called Ngaltinga Clay, which in turn is overlain by calcareous sediments. The marked change from an oxide-dominated weathering regime to a carbonate weathering regime is estimated to have occurred at about 500 to 600 ka, and is interpreted as a major arid shift in regional climates.

Similar arid shifts are reported from Lake Bungunnia in the Murray Basin (An *et al.* 1986, *Palaeo.*[3] *54*, 219-239) and Lake Lefroy in southern Western Australia (Zheng *et al.* 1998, *Global & Planet. Change 18*, 175-187), where changes from lacustrine clays to evaporites and dune sediments are estimated to have occurred between 400 and 700 ka, and about 500 ka, respectively. An increase in aeolian dust input to Tasman Sea sediments also occurs in the last 400 ka (Hesse 1994, *Quat. Sci. Rev. 13*, 257-272).

At Timaru, in the south Island of New Zealand, six major loess layers overlie basalt dated at 2.5 Ma. Luminescence dating of the youngest 3 loess layers indicates they accumulated during the last 3 major glacial periods (isotope stages 2, 6 and 8). All six loess layers are of normal polarity and are inferred to be younger than 0.78 Ma (Pillans *et al.* in press). Loess production and accumulation are controlled by a complex interplay between glacial and periglacial activity in the Southern Alps, fluvial and aeolian sediment transport on the Canterbury Plains, and climatically driven regional vegetation changes. The last glacial maximum is inferred to have been considerably drier than present in New Zealand (Pillans *et al.* 1993, *Quat. Sci. Rev. 101*, 283-304.) and the same was probably true of earlier glacial periods in which loess accumulated.

Between 600 and 900 ka, oxygen isotope fluctuations in deep sea cores show a pronounced change in frequency, from a 40 ka (obliquity dominated) to a 100 ka (eccentricity dominated) pattern. At the same time, glacial-interglacial amplitudes increased, with a marked enrichment of glacial $d^{18}O$ values consistent with larger continental based ice-sheets. Colder global temperatures, and lower sea levels during glacials may have played a part in the mid Pleistocene arid shift recorded in southern Australia and New Zealand. Associated variations in the strength of the warm Leeuwin Current (McGowran *et al.* 1997, *Palaeo.*[3] *136*, 19-40) may also have affected regional rainfall patterns in southern Australia.

THERMOLUMINESCENCE DATING IN AUSTRALIA: FROM LAKE MUNGO TO JINMIUM AND BACK

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Thermoluminescence (TL) dating has found numerous applications in Australian archaeology. In the 1970s TL dating was used to determine the age of ancient Aboriginal fireplaces on the lunettes of Lake Mungo, western new South Wales. This chronology was later validated using TL to determine the depositional age of sediment in which the firehearths are buried. Since these times sedimentary dating, using luminescence techniques, has been widely used by archaeologists leading to the controversial age estimation of human occupation of northern Australia before 116 ka. This paper provides an insight into these findings from the shores of Lake Mungo to Jinmium and back.

SYSTEMATIC CHANGES TO HILLSLOPE MORPHOLOGY WITH STREAM ORDER AND THEIR IMPLICATIONS FOR SEDIMENT DELIVERY TO STREAMS

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Sediment yield per unit area generally decreases with increasing catchment size. This has been attributed to increased opportunities for sediment storage and, in some instances, lower mean erosion rate in large catchments. Despite these widely accepted views there has been little systematic examination of potential sediment storage or hillslope erosion rate with increasing catchment size. It is often not specified, for example, whether the predominant sediment stores are in alluvial features or footslope deposits, or indeed whether sediment storage is more significant than decreasing mean erosion rate.

The answers to such questions have a bearing on sediment and nutrient control, because they influence where in a catchment riparian buffers might be most effective in reducing sediment delivery to streams. It will also be argued that patterns of sediment delivery impact upon landform evolution in a way which is poorly represented in current models of landform evolution.

We examine systematic patterns in hillslope morphology and explore their implications for sediment delivery to streams. Analysis of Horton's laws of network composition suggest that hillslope area per unit length of stream is moderately large for first order streams, lower in second order streams, and then rises sharply as stream order increases. This pattern is confirmed from a DEM of a 5 km^2 catchment. The DEM also shows decreasing mean hillslope gradient, streamside gradient and drainage density with high stream order, and increasing presence of low gradient footslopes. Such patterns are not produced by landform evolution models that simulate dynamic equilibrium where erosion is balanced by uplift at all points.

Applying the topographic patterns to simple laws for sediment transport shows that sediment delivery to streams decreases sharply with increasing catchment area without considering sediment storage. There are few significant sediment stores in the 5 km^2 catchment that is considered. For this, and other stated reasons, we believe emphasis should be given to locating riparian buffers adjacent to first order streams.

RELATIVE IMPACT OF CLEARING OF RIPARIAN VEGETATION, DE-SNAGGING, ARTIFICIAL MEANDER CUTOFFS AND HIGH MAGNITUDE FLOODS ON THE MORPHOLOGY OF THE LOWER LATROBE RIVER, GIPPSLAND, VICTORIA

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Clearing of riparian vegetation, de-snagging and installation of artificial meander cutoffs are impacts that have affected the alluvial reaches of almost all large rivers in eastern Australia since European settlement. There are, however, few published data of sufficient detail to enable an assessment of the *relative* impact of these artificial channel disturbances on the morphological, planform, hydraulic and sedimentological characteristics of east Australian rivers. Detailed archival data and reconstructions of channel dimensions and sedimentological characteristics from meander cutoffs along the lower Latrobe River in Gippsland, Victoria, provide an excellent opportunity to address this issue and to extend the implications of these results to interpretations of channel change in alluvial rivers across eastern Australia.

At the time of European settlement, the lower Latrobe River was an example of a low gradient, low capacity, low energy suspended-load river. The mean annual flood (RI 2.33 years) was approximately 200 m3s-1, but bankfull channel capacity for the lower Latrobe River at Rosedale (catchment area 4,100 km2) was in the vicinity of 60 m3s-1. Flow duration curves indicate that about at the time of European settlement, the Latrobe at Rosedale flowed at a bankfull or higher stage for more than 50 days per year. The average bankfull width of the Latrobe River, as determined from pre-European meander cutoffs, was 25 to 30 metres.

The Latrobe Valley was settled by Europeans in the 1840s, and by the 1890s channel banks along much of the river had been cleared of trees to such an extent that early attempts at de-snagging were hampered by a lack of large lift trees. A detailed survey entailing some 283 cross-sections along a 100 km length of the lower Latrobe River was completed in 1925. Comparison of the bankfull dimensions of the Latrobe channel as recorded by the 1925 survey with bankfull dimensions of pre-European and early settlement meander cutoffs revealed no measurable change in the bankfull width of the river since European settlement until 1925.

The decade from 1927 until 1937 provided the most frequent large floods in the Latrobe River since available gauging records. Floods over this time include the 1st, 3rd, 4th and 5th ranked floods of a 60 year annual maximum record. The largest event had an estimated recurrence interval of 350 years and a discharge in excess of 15 times the mean annual flood. The frequent high magnitude floods of the 1920-30s caused only a small increase in bankfull width over a short length of the river. The high magnitude floods of the 1920-30s had a low geomorphic effectiveness despite channel banks having been largely cleared of trees prior to the floods.

In response to the record flood of December 1934, an extensive de-snagging program was undertaken from 1936 to 1940. Detailed hydraulic data from the Rosedale gauge record only small increases in channel capacity resulting from the 1936-40 de-snagging program. Floods ranked 2nd and 6th on the annual maximum series occurred in 1952 and 1953, but measurements of channel dimensions in some 24 artificial meander cutoffs installed between 1954 and 1958 suggest that these flood events also caused little change in the bankfull width of the river.

The greatest changes in the dimensions, hydraulic and sedimentological characteristics of the lower Latrobe River were produced by relatively minor floods of the 1970s after the installation and abandonment of numerous (53) artificial meander cutoffs over the 1950-70s. The artificial meander cutoffs created numerous upstream migrating knick zones which incised and destabilised the thalweg, generated excess (relative to the prior morphology of the river) bedload sediment, undercut and collapsed channel banks. Numerous artificial meander cutoffs have also been installed along the Macalister, Cann and Hunter Rivers and are likely to have produced similar effects to those described for the Latrobe River.

THE INFLUENCE OF LARGE WOODY DEBRIS IN THE MORPHOLOGY AND STABILITY OF S.E. AUSTRALIAN STREAMS: SOME EVIDENCE AND SPECULATIONS

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Vegetation exerts a powerful influence upon stream channel morphology and stability. Many of the fundamental geomorphic models in the literature come from North American and European stream systems. In this paper we suggest that there are fundamental differences between Australian and North American riparian timber that may contribute to fundamental differences in stream form and process in the two regions.

We will discuss and contrast the following four key issues for Australian and North American streams and vegetation: the rate of delivery of timber to Australian streams from slopes and floodplains, the breakdown and transport of the timber once it is in the stream, the resulting density of large woody debris accumulations, and the general implications of large woody debris for Australian stream geomorphology and stream management.

We conclude the following.

1. Under pre-European conditions, delivery rates of timber to Australian streams may generally have been slower than in North American streams. This was because some important mechanisms that deliver trees to North American streams are absent from most Australian streams (eg. debris flows), and because other mechanisms (eg. lateral channel migration) were slower.

2. Comparing a sample of 17 Australian (*Eucalyptus* and *Acacia* spp.)and 17 North American tree species, suggests that the Australian trees are generally denser than water (green density) whilst North American species that we reviewed will always float. In addition, the Australian species are harder, stronger, and more durable. They also have a different shape than many North American riparian species, being more branched, with a higher centre of gravity.

3. There is some evidence that timber in Australian streams was distributed more evenly throughout the length of a stream, whereas it tends to be more clumped in the headwaters of North American streams. This difference can be explained by the higher density, strength and large branches of many Australian riparian species which mean that they stay where they fall in a stream. By contrast, North American trees are often light and cylindrical and so roll downstream to accumulate in jams or wash out of the system. The poor transport of timber in Australia is assisted by the generally lower stream powers of Australian streams at European settlement.

We speculate that the density and longevity of timber stored in streams played an important role in the geomorphology of many SE Australian streams. Examples of processes that were influenced by large woody debris accumulations are flood frequencies, vertical accretion processes, and channel avulsions. Removing the timber from streams for flood mitigation certainly played a role in the dramatic channel changes that occurred in some streams after white-settlement.

TAMING SLUGS: UNDERSTANDING AND MANAGING ANTHROPOGENIC SAND IN A LARGE CATCHMENT

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Since the 1880, the Glenelg River in Western Victoria, and its tributaries, have been invaded by up to 8 million cubic metres of sand as a result of stream and catchment erosion. The sand is the major stream management problem in the catchment. Slugs of sand are interacting with incised streams and at tributary junctions, to produce an interesting pattern of sand movement, and channel recovery. An appreciation of the geomorphic processes has allowed us to develop a commercial sand extraction regime that will assist in the rehabilitation of the stream.

DISTANT VIEWING

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V in V-valley landscapes keep the same geometry as denudation keeps up roughly with uplift. The sawtooth pattern is in a steady state of "tolerable erosion" where removal equals renewal. The time taken for each increment of the weathering profile in its evolution from rock to stage of saprolite is the residence time for that increment and is the inverse of the rate of denudation. The stages being less for high rates of denudation. The rate of leaching determines what stage of weathering is reached and this varies with the type of rock, rate of percolation, and weathering rate constants.

Some solutions are found by mass balance methods in small catchments where mineral dissolution and rate of denudation can be calculated which are similar to answers found by other means.

In this paper other means are AT A SITE in the catchments as on ridge crests or steep slopes. Amount of weathering is approximated by using various weathering indices from chemical analyses which are compatible internally. The rate of weathering (R) is given by:

$$R = 100 \frac{w}{d}$$

Where w is the rate of weathering and d is the rate of denudation. The limits of 0 to 100% weathered rock are known and sometimes the time taken to weather a given thickness can be derived approximately from elsewhere in the same lithology where,

$$t1\ w1\ k1 = t2\ w2\ k2$$

t is the thickness of bed, w is the amount of weathering, and k is the weathering rate constant. The link between catchment and at a site method is the rate of leaching of the regolith, here mainly weathering profiles. Around the world this averages roughly 4 mg $cm^{-2}a^{-1}$ (actually 1 to 7).

In northeast Papua with mountains steadily rising a block of basic-ultrabasic rocks (I), a part of an obduction plate, gave rise to a thick (1000m) series of fanglomerates (II) called Domara River Beds (Qpd) which again rose to high hills during the Pliocene and Pleistocene shedding recent fans III and modern alluvial plains (IV). The degree of weathering is given roughly by grain counts (inverse of fresh minerals i.e. clay) I, O; II, 10-25; III, 20-40; IV, 40-50. Instrument methods agree well in the mud (silt and clay) where large amounts of fresh minerals occur. Chemical analyses of sandstone and siltstone; not mudstone, in Qpd give degree of weathering I, O; II, 7; and III 15. From this data we can get an estimate of rate of weathering from both laboratory and field data and the residence time, rate of denudation, rate of sedimentation and relief. The estimated relief is 400m and the actual relief is similar (350-500m). This model can be applied to the Miocene sandstone and mudstone of the Aure Trough in the Gulf District of Papua where 15 chemical analyses and several thousand grain counts are available.

The basic-ultrabasic rocks are mainly composed of olivine (some), pyroxene and plagioclase and these weather in a linear fashion in the laboratory. Transport distances are a few kilometres and yet two which denudational cycles are present.

DIFFERENTIAL GPS USED TO MAP GEOMORPHIC FEATURES IN KAKADU NATIONAL PARK

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A coastal monitoring node for the Alligator Rivers Region, has been developed at the Environmental Research Institute of the Supervising Scientist (*eriss*) in the Northern Territory. The objective of the coastal monitoring node was to develop a regional capacity to measure and assess change on the floodplains and coastline of Kakadu National Park, the wider Alligator Rivers Region and the Wet-Dry tropics in general. The initial aim in the establishment of the coastal monitoring node was to provide a survey and monitoring framework using a differential Global Positioning System (GPS) to accurately georeference, store information, and provide baseline data.

A differential GPS was used to provide an accurate georeferencing capability as part of a monitoring framework for the Alligator Rivers Region. To increase the accuracy of the differential GPS, a permanent GPS base station has been established at Jabiru Airport as part of the AUSLIG Fiducial network. Using differential GPS equipment, accuracy in the order of a few centimetres in the horizontal plain can be achieved, compered to tens of metres for hand held GPS units.

The establishment of dGPS capability has not only provided the basis of a coastal monitoring node but has also provided flexibility for mapping and georeferencing field sites for all existing projects and any number of future projects. It has provided a survey framework for baseline monitoring and has enabled us to develop the capacity to locate, map and georeference geomorphic and biologic features in the ARR. The differential GPS has successfully been used to map geomorphic and biologic features such as saltwater intrusions, mangrove distributions, wetland areas, channel and creek cross-sections, tidal creek extensions etc. Some of geomorphic applications and results using the differential GPS will be shown and discussed.

QUATERNARY GLACIAL HISTORY OF THE COBB VALLEY AND ADJACENT AREAS, N. W. NELSON.

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The NW Nelson area was extensively glaciated during the Quaternary, but, despite some excellent observations by early field workers, the glacial history of the region is remarkably poorly known. Here we report a summary of findings from an ongoing project investigating the glacial history of the Cobb Valley system, N.W. Nelson. The upper part of the Cobb forms a classic U-shaped valley in the Tasman Mountains. The floor of the valley lies between 800 and 900 m and it is surrounded by a Tableland at about 1100 to 1300 m. There is extensive evidence of glaciation both in the valley and the adjacent tableland.

Glacial advances during the Last Glaciation (Otiran) are recorded as a suite of terminal moraines as far down valley as the head of the Cobb Reservoir. These moraines are, however, neither particularly large, nor extensive, and a pollen record from a kettle hole in the second most advanced moraine initiates at 17,000 Libby radiocarbon years ago, indicating a relatively early retreat from the Last Glacial Maximum (stage 2) ice front.

Roche Mountoneés occur in physical association with the terminal moraines but represent very different sub-glacial conditions. These features in association with ground moraines (previously mapped as terminal moraines) and high level lateral moraines extend many kilometres down valley from the last clear terminal moraine and are remnants of an earlier much larger advance. During these advances ice was at least 300 m deeper in the valley than during the stage 2 advance. These advances are undated but since the stage 2 event in New Zealand is of equivalent size to all other Late Quaternary advances, the deposits may represent mid- or Early- Quaternary events when the local mountains were at a higher mean elevation.

Glacial deposits also occur in a high level valley remnant (200 m above the modern valley floor) on the south side of the Cobb. This valley system is part the former Cobb drainage before it was captured by headwater streams of the modern system. This capture took place during uplift and tilting in the Kaikoura Orogeny. The capture is very insecurely dated but probably occurred during the Late Pliocene to Early Pleistocene. The deposits either represent the product of Late Pliocene/Early Quaternary glacial advances down the paleovalley or spill over from glaciation down the main Cobb Valley.

SILCRETE FORMATION IN THE MT. WOOD HILLS AREA, NORTHWEST NEW SOUTH WALES.

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The Mt. Wood Hills area is situated in the Sturt National Park, northwest NSW, 20 km east of Tibooburra. The landscape is dominated by scarps up to 30 m high that run approximately N - S through the area. The barren regional landsurface has a shallow easterly dip of 4 - 5°, and is covered extensively in silcrete and lateritic gibber. Exposed, strongly weathered and silicified Early Cretaceous sediments deposited in the Eromanga Basin dominate the regional geology. A thin, partially silicified Early Tertiary cover of the Lake Eyre Basin sediments is seen in places. At least three separate episodes of silcrete formation have been recognised in this area.

The oldest recognised silcrete, the 'columnar silcrete', commonly has pedogenic features such as columns, candle wax drippings and a concretionary top layer. It is pale-coloured and formed at or near the landsurface within the exposed, folded and faulted Early Cretaceous sediments. It outcrops as pavements in eroded gullies and as prominent blocks along scarp edges, where thicknesses can reach 5 m. The silcrete has been gently deformed, with sheets tilted under flat-lying younger sediments.

A younger silcrete, the 'sandstone silcrete', has silicified quartzose gritty red sandstone deposited over the Early Cretaceous sediments and columnar silcrete, and incorporates eroded water-worn columnar silcrete clasts reaching 50 cm in diameter. This silcrete often infills joints or depressions in the columnar silcrete, and outcrops on scarp and valley sides reach 3 m thick. It is predominantly massive, but can show pedogenic candle wax drippings that terminate at the silcrete clasts. Its age is probably Late Cretaceous, as it is overlain by Early Tertiary Eyre Formation sediments. There is no evidence of post-silcrete deformation.

The youngest silcrete has been named the 'white pebble silcrete', as it contains shiny rounded milky vein quartz pebbles, often in lenses or bands, as well as petrified wood. It has silicified Early Tertiary (Palaeocene to Middle Eocene) Eyre Formation gravels and older weathered sediments that have incorporated relict Eyre Formation pebbles. Its outcrop is sparse, massive and shows no pedogenic features. Silica cement varies from yellow opaline to grey or buff quartzose to blue-grey anatase-rich.

There is a fourth silcrete of uncertain age and origin, seen as clasts reaching 1 m diameter within the Eyre Formation sediments. These silcrete clasts have irregular shapes and a very smooth glassy surface that appears to be a thin deposit of opaline silica over the entire surface, including fractures pits and depressions. This silcrete is generally massive blue-grey with swirls of anatase.

POST MID-MIOCENE EPISODES OF ACTIVE UPLIFT OF INTRAPLATE HIGHLANDS: THE MACQUARIE RIVER VALLEY, AUSTRALIA

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The denudational history of the Macquarie River valley in the Transition Zone was investigated to test Bishop and Brown's (1992) model of episodic isostatic uplift in response to denudational unloading of the highlands and sediment loading of the basin. Long profiles of the basalt filled Middle Miocene valley, the inset Pliocene bedrock valley and highest terrace were reconstructed to look for evidence of incision and deformation due to highland uplift. The timing and nature of sedimentation in the valley were determined to identify periods of base level stability and instability. The history of erosion and sedimentation in Wellington Caves, located in the Bell River (a major tributary) was also included to provide additional evidence between basalt extrusion and erosion of the Pliocene valley.

It was found that the Middle Miocene valley and the Pliocene valley showed evidence for two periods of major incision, the first during the Middle Miocene, the second during the Late Miocene. The long profiles of the valleys showed clear evidence of deformation and oversteepening in the Transition Zone, which triggered knickpoint retreat during each incisional period. The evidence of extensive subaerial erosion from Wellington Caves during the Early Pliocene is consistent with the knickpoint retreat. The periods of incision and oversteepening in the long profiles thus provide clear evidence for uplift events of the highlands during the Middle Miocene and the Late Pliocene.

It was found that sedimentation in the valley, between the Middle Miocene and the Late Pliocene was conformable, which indicated a period of base level stability. Minor incision resulting in terrace formation and lateral river migration, forming a ridge and swale floodplain, began in the Early Pleistocene. The terrace long profile does not show evidence of significant divergence. It does, however, show convergence with the floodplain towards the Darling Basin. The implications of this convergence for highland uplift in the Pleistocene is unclear.

The evidence for uplift in the Transition Zone in the Macquarie River valley shows that uplift is episodic, occurring over a return period of millions of years, which implies tectonic (active) force. The valley length over which inflexion occurs (> 50 km) provides evidence for long wave flexure of the lithosphere. The timing and response of the Macquarie River valley to uplift shows that the model of Bishop and Brown (1992) does not apply to the entire highlands. The suggestion of similarity between other valleys in the Darling Basin, which drain from the highlands, may indicate that uplift of the highlands operates on a regional scale.

USING THE SOIL STRATIGRAPHY OF LOESS TO RECONSTRUCT LANDSCAPE HISTORIES OF NORTH-EASTERN AND WESTERN LOWLANDS OF SOUTH ISLAND, NEW ZEALAND.

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Soil stratigraphy of loess has been established throughout the lowland regions of South Island and the number of loess sheets increases from one to six on successively older late Pleistocene surfaces. Loess stratigraphy provides a means for regional correlation of buried geomorphic surfaces within and beneath these cover beds. Partial removal and redeposition of loess leaves a record of erosional modification of original depositional landforms. Soil stratigraphic features in contrasting bioclimatic environments of South Island can be grouped into three regions characterised by: Fragic Pallic and Argillic Pallic Soils (Fragiustochrepts and Fragiudalfs), Firm or Orthic Brown Soils (Dystrochrepts), and Perch-gley Podzols (Alaquods). The first dominate in the eastern region and the last dominate in the western region. Buried soils in loess have similar morphological features to surface soils. Because of the slow, incremental nature of loess addition, soil formation continues during loess accumulation and the magnitude of these changes influences subsequent topdown soil formation when loess addition is minimal. The net effect of the upbuilding and topdown soil development determines the morphological expression of soils and buried soils which are used to establish a loess stratigraphy. The widespread incorporation of a c. 22.6 ky rhyolitic tephra from the Taupo Volcanic Centre is used to compare regional differences in loess accumulation since the last glacial maximum. Luminescence dating of older loess sheets is ongoing but has some problems of interpretation. Soil stratigraphy worked out from best section analysis has proved to be the key to regional correlation of buried geomorphic surfaces on depositional landforms such as moraines, terraces and piedmont plains.

North-eastern study: Charwell basin is in a non-glaciated region of high tectonic uplift adjacent to the strike-slip Hope fault. In the late Pleistocene there have been multiple episodes of basin aggradation interspersed with episodes of valley incision and terrace formation. Because of tectonic uplift, successively younger aggradation events have started from lower base levels (Bull, 1991). Felsic loess is widespread and slightly to moderately weathered. The youngest late Pleistocene aggradation surface has thin loess modifying the upper horizons of Brown Soils formed in alluvium. Successively older aggradational surfaces have from one to three loess sheets with Fragic Pallic and Argillic Pallic Soils. Buried soils in loess have comparable morphologies. The correlation of aggradational and degradational terraces between drainages of the present and prior rivers was determined from the presence, thickness and soil stratigraphy of loess. Erosional modification of successively older terraces was interpreted from: (a) the accumulation and erosional modification of successive loess sheets, and (b) episodic infilling and excavation of loess colluvium in channels incised into underlying terrace gravels. The Charwell study provides a model of landform change over the past c. 200 ky that is applicable to other basins of the north-eastern South Island.

Western study: Saltwater Forest lies on the piedmont west of the Southern Alps, a region of very high rainfall and low tectonic uplift. Glacial moraines and aggradational terraces are formed from felsic debris. Felsic loess is widespread with highly weathered Perch-gley Podzols. Buried soils have comparable morphologies. During the periods of maximum loess addition soil development was intense and entire loess columns are highly weathered and quartz dominated. The recognition of soil stratigraphic boundaries is commonly obscured by diagenetic overprinting of buried soils where the loess sheets are thin. Moraines are nested and it is possible to establish the age sequence. The relative length of time between glacial advances can only be estimated by examining the soil stratigraphy within loess coverbeds and in underlying sediments. In the absence of tectonic uplift and associated base level changes the establishment of the age sequence of aggradational terraces is difficult. Loess thickness and soil stratigraphy provide a means of recognising and mapping aggradational surfaces and correlating them with moraines. On the assumption that the loess deposition intervals were regionally synchronous, the soil stratigraphy of the loess has been used for the correlation of moraines and aggradational surfaces within the western piedmont.

References:

Almond, P.C. 1997: Soils and geomorphology of a lowland rimu forest managed for sustainable timber production. PhD thesis Lincoln University Library.

Bull, W.B. 1991: Geomorphic responses to climate change, chapter 5, Oxford University Press.

AEOLIAN ADDITIONS TO THE SOILS OF SOUTHEAST AUSTRALIA

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The amount and nature of aeolian dust additions to the soils of southeastern Australia were determined. Samples were taken from several sites in the Central Highlands of NSW, the Macquarie Valley and Murray Basin, selected for the mineralogy of parent substrates and ease of interpretation and soil formation. Signatures of exotic aeolian material were firstly identified using detailed particle size analysis and mineralogical identification of soil and substrate through X-ray diffraction (XRD) and thin section analysis. The rate of accession was calculated by the use of thermoluminescence dating of dust stored in source bordering sand dune deposits of the Macquarie Riverine Plain.

Aeolian signatures were found to be ubiquitous across diverse substrates, irrespective of location. The signature identified consisted of discrete mineral grains, of which quartz is the major component. Accessory minerals include felspar, hematite, clay minerals and micas. The modal size of the aeolian accession is 30-40 μm, which has been identified across diverse substrates over hundreds of kilometres. Clay content of the aeolian dust was found to be consistently low. The aeolian content of the soils from the western and cental areas of the highlands was estimated to be as much as 25%.

The clay pellet parna model (Butler, 1956) which has been so widely applied to the Murray Riverine Plain, other areas of Australia and even Mars (Greeley and Williams, 1994, Icarus) was found to be inappropriate for the identification of the aeolian component in these soils. With the automation and sophistication of contemporary measuring equipment, dust addition to soil can be more accurately defined and quantified than has so far been the case. Generalisations and general classifications of dust deposits in Southeastern Australia require detailed reconsideration using detailed analysis of suitable diagnostic sites.

LINKING MAGNITUDE-FREQUENCY RELATIONS FROM HILLSLOPE TO FLOODPLAIN

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A major research question facing geomorphologists and resource planners is how to evaluate the downstream impact of land use changes that have occurred, or are occurring, on upland hillslopes. Although the relation between sediment production in upland areas and sediment yield at the basin outlet has been the subject of investigation for over half a century, understanding the connections between cause and response is far from complete. Furthermore, spatial and temporal variations in erosion processes and thresholds, and effects due to prior events make it particularly difficult to determine the role that events of a given magnitude play in the production and dispersal of sediment, especially in large catchments.

Magnitude-frequency relationships between hillslope and channel response have been used to assess the role that storms of different magnitude play in generating and transporting sediment in the 32 km^2 Tutira catchment and the 2205 km^2 Waipaoa catchment in the erodible soft-rock hill country of the east coast of the North Island, New Zealand. Shallow landsliding is an important erosion process in this area and this paper is focused on the contribution that this process makes to the sediment yield of both these catchments. The high-resolution sediment record from Lake Tutira revealed the relationship between event magnitude and sediment yield during the last 93 years, and illustrates the extent to which climate and land use change have affected the amount of sediment generated over the last 2250 years. Magnitude-frequency relationships for hillslope erosion and downstream deposition are closely related in the Tutira catchment, and large magnitude, low frequency landsliding events have been responsible for much of the deposition in lake Tutira during the historic period. In the Waipaoa catchment, process that affect sediment generation and output are examined using a sediment budget approach. By contrast with the Tutira catchment, landsliding makes a smaller relative contribution to catchment suspended sediment load than does the combination of other erosion processes such as gully, earthflow and channel erosion. Furthermore, suspended sediment data suggest that 76% of the suspended sediment load is transported by flow events less than bankfull discharge. Hence, large storms have a diminished role compared with the cumulative influence of more frequent, lower magnitude events.

Comparison of the forms of magnitude-frequency relationships of erosion processes and sediment yields, and deviations from these relationships, provide a measure of the potential importance of temporal variations of erosion resistance, transport lag times, temporary storage, and especially for large catchments, the general diffusion of the magnitudes and frequencies of sediment contributions from the spatially variable distribution of erosion processes within the various tributaries.

HOW MOBILE IS YOUR RIVER? PREDICTING MEANDER MIGRATION RATES FROM READILY MEASURABLE STREAM VARIABLES

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Meander migration comprises a significant source of sediment from Australian streams, and attracts at least $15 million in structural controls and revegetation work annually in Australia alone. Predicting how fast meander bends migrate across their floodplain would be useful for understanding rates of floodplain reworking, as well as for management questions such as "how much sediment is being delivered from bend erosion", or "will this bridge be outflanked by erosion". Despite many publications on the subject, there are no easy-to-use tools for predicting rates or directions of migration. Tools that exist either require measurement of too many variables to be useful for most management situations, or are too specific to a particular river to be generally applicable. A global data set was therefore compiled of 90 meandering river reaches, from a wide variety of climates and sediment types, to determine empirical meander migration relationships. Mean and median migration rates for the whole data set were 3.4 m/yr and 0.9 m/yr, or 3.1% and 1.6% of channel width respectively, with a range from 0.1 m/yr to 75 m/yr (0.2% to 25% of channel width). The range of rates suggests we need to go beyond simple rules of thumb, such as the oft used 1% of channel width per year for determining meander migration rates.

The distribution of meander migration rates in a relatively homogenous river reach typically follows a log-normal form. If plotted decumulatively, the population distribution of meander migration rates on individual river bends forms a probability curve (Figure 1). By non-dimensionalising migration rate by dividing by channel width, rivers of different scale are made comparable, and thus a family of probability curves is described. Predicting the meander migration of an individual bend in a river reach then becomes a question of identifying which curve in the family of curves best corresponds to the river under investigation, and then where the individual bend sits on the probability distribution.

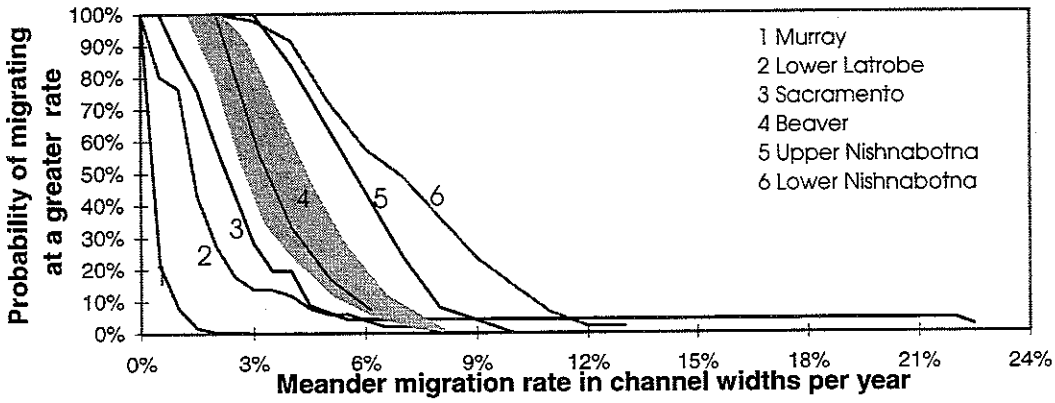

Figure 1: Decumulative curves of meander migration rates of selected streams. Percentage values refer to probability that erosion rate is higher than given. The area in grey is a sample probability domain.

Statistical analysis of the global data set was used to determine a relationship between flow, channel and sedimentological variables, and mean meander migration rate. The best relationship was between volumetric erosion rate (MD) and bankfull channel width (W), resistance of the bank sediment to fluvial entrainment (B_{str}) (which, for this analysis, was simply assigned an ordinal value according to known D_{50} - shear stress relationships, and taking into consideration sedimentary layering and sediment size distribution), valley slope (S), and width:depth ratio (W/D), $MD = W^2 S^{0.35} e^{(0.41Bstr-0.037(W/D)-5.05)}$ (R^2 = 92.4%, $p < 0.01$). Using this relationship it is possible to identify a corresponding probability curve from the family of curves, and thus a probability domain (defined by the distribution of errors associated with the predicting formula) within which a given river bend is likely to lie (Figure 1). From this domain, it is possible to predict the probability of any randomly selected bend migrating at a given rate.

Further work is required to identify the effects of individual bend characteristics such as bend curvature and length, and to determine a simple and rigorous relationship between resistance of banks to fluvial scour and sediment size.

THE INFLUENCE OF GEOMORPHOLOGY ON THE LOCATION OF ABORIGINAL SITES IN CENTRAL WESTERN AUSTRALIA

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The area studied lies between 115° and 117°30' E and 26°30' and 28°30' S. It is known colloquially as the Murchison Basin, but includes the Greenough River system as well as the Murchison and its tributaries. It comprises the western part of the Yilgarn Craton, between the Darling Fault and the physiographic divide separating the exoreic river systems from the inland saline basins. The craton is composed of faulted and metamorphosed late Archaean shield rocks that have been tectonically stable since the Mesozoic, but have been subjected to considerable weathering. The surface of the craton now undulates between 300 and 500 m amsl, but is pierced by younger intrusive hard rocks that form prominent hills and ranges reaching heights of 600 m amsl and by 'whalebacks' or granite domes.

This palaeolandscape was blanketed during the early Tertiary by unconsolidated sediments that are now lateritised, although precisely when and how this occurred is debated. The eroded remnants of this duricrust are preserved along the major drainage divides as breakaways and mesas. The alluvium and aeolianites filling the drainage systems are the products of duricrust erosion. They can be divided into older cemented, lithified or semi-consolidated deposits probably of late Tertiary age and younger unconsolidated deposits of Quaternary age.

Thus, overlying the Archaean basement, the Murchison landscape comprises two planar surfaces: an upper duricrust plateau edged by breakaways <15 m high, and a lower alluvial plain over which the rivers now flow. Breakaways chiefly occur on the interfluves west of the Murchison River and at the heads of the drainage systems. East of the river, only isolated mesas are preserved.

My ultimate aim was to begin to understand how its Aboriginal occupants had used the Murchison land-scape prior to European arrival. Therefore, I needed to identify environments in which well-stratified archaeological deposits susceptible to radiometric dating were preserved from which I could excavate temporally controlled stone artefact sequences. The artefacts now scattered extensively on the alluvial plain were clearly inadequate in this regard, since they could not be dated either typologically or radio-metrically. Thus, I needed to locate rock shelters used by people. Initially, I investigated granite domes, because a major overhang has developed at Walga Rock, but it appears to be unusual. The sides of most domes emerge smoothly from the surrounding regolith. Artefacts discarded at their perimeters are as undatable as those found elsewhere on the present ground surface.

The only archaeologically interesting rock shelters identified had formed in 'breakaways'. However, any given stretch of breakaways usually contained only a few shelters large enough to accommodate humans, because shelter shape and size appears to depend mainly on local topographic and geomorphological features. Of those few shelters that were potentially habitable, in only an even smaller number did the configuration of the floor and roof ensure the preservation of any depth of deposit. Dozens of shelters had artefacts thickly scattered on the talus, but the deposits under the overhang either contained no artefacts or were too shallow to merit excavation. Thus, in any given line of breakaways none, or perhaps only one or two, preserve evidence that Aborigines used them in the past. Moreover, breakaways are inherently unstable, but the speed with which overhang collapse occurs is unknown. From the few ^{14}C dates available, shelters may remain habitable for several thousand years, but none has yet yielded deposits >10 ka old. These findings have important implications for predictive models of site location.

HOLOCENE EUSTATIC AND TECTONIC EFFECTS ON THE GEOMORPHOLOGY OF THE SOUTHERN NEW BRITAIN COAST, PAPUA NEW GUINEA

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The central portion of the southern coast of New Britain is characterized by a coastal limestone scarp, seaward of which is a shore platform; the oceanward edge of this slopes steeply offshore. The appearance of the shore platform differs greatly along the coast, and was studied in detail in 2 areas, the Arawe Islands, and, 50 km to the east, Kandrian.

In the Arawes the shore platform is submerged at high tide and just exposed at low tide. The limestone cliff rises 20 m above the platform; at its base is a prominent notch with a well-marked step about 1 m above the platform. This step was probably formed during the Holocene high sea level of + 1-2 m at around 6,000 BP; a nearby dead coral reef, elevated about 1 m above present sea level, gave an age of 5,200 ± 140 BP.

In the Kandrian area the appearance of the coastline is quite different. Here, seaward of the cliffs which rise 80 m asl, are soil-covered limestone platforms elevated several meters above sea level. The bases of the cliffs are generally covered with rubble and soil, except at one site where there are 2 broad notches, one at the cliff base and the other about 1 m higher. The raised platforms terminate at their seaward edges in a shore platform up to 20 m wide, lying more or less at present low tide level. Excavations on the raised platforms have shown that they are covered with beach sand and coral up to 2 m thick, overlain by generally less than 0.5 m of soil. The oldest age from an in situ coral head is 5,760 ± 600 BP.

It seems that the raised platforms at Kandrian were covered by shallow water during the 6,000 BP highstand, just like the platforms in the Arawes. Subsequently the Kandrian platforms were uplifted several meters by a tectonic event. Independent evidence of this comes from a local legend. A masalai (spirit), Arung, came to the mainland from an offshore island, accompanied by a storm and earthquake that uplifted the ground and caused the sea to retreat.

The age of this uplift is constrained by the youngest reliable dates obtained from the shell and coral on the raised platforms, of 2,020 ± 70 BP and 1,990 ± 70 BP. Thus the uplift probably occurred around 2,000 years ago, of perhaps slightly later.

The difference in the geomorphological history of the Kandrian and Arawes coasts has strongly affected the preservation of archaeological material in the two areas. During the Lapita period, 3,500 - 2,000 BP, people lived in stilt villages built along the coast in shallow water in protected locations. The baffling effect of the stilts caused sand banks to build up beneath the villages. In the Arawes, artefact material within these sand banks is well preserved in waterlogged sediment; pottery, obsidian and shell artefacts have been recovered, along with food plant remains and even wooden posts. In the Kandrian area, by contrast, the sand banks beneath the Lapita villages were uplifted and became dry land around 2,000 years ago. The sediments dried out and the resulting aerobic conditions destroyed any organic remains. Thus archaeological excavations around Kandrian have recovered only pottery, obsidian and shell.

TSUNAMI SEDIMENTARY DEPOSITS NEAR STEAMERS BEACH, JERVIS BAY, N.S.W. AUSTRALIA

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Evidence for the impact of 5 or 6 Holocene tsunami is now recognised at over 20 locations on the southern coast of NSW. Erosional features include bedrock sculpturing and erosion of Last Interglacial Barriers. Depositional features range from stacked boulders and boulder trains through highly bi-modal sand and gravel mixtures, to marine sands with few, if any, coarse clasts. Tsunami run-up heights vary with changes in coastal topography and the width and slope of the continental shelf. The protruding headlands of Jervis Bay, lined by sea cliffs which plunge deeply below sea level and the steep offshore slope, have produced the greatest run-ups observed along this coast.

Steamers Beach on the south headland is a small pocket beach with 4 km of straight, unbroken cliffline extending to the south-west. A tsunami striking these cliffs from the south to south-east will generate a mach-stem wave travelling normal to the cliff. This will increase in height as it travels, amplifying the original wave, until it enters the cliff lined embayment flanking Steamers Beach. The resultant trapping of wave energy is expected to generate greater run-ups at this location than elsewhere on the headland.

Three distinct tsunamigenic facies are seen at Steamers Beach. The lowest unit is a mixture of sand, gravel and mud which has consolidated into a hard brown, massive horizon. This poorly sorted deposit contains abundant material both too fine and too coarse to be of aeolian origin. The mud does not fill the voids in the deposit, rather it occurs as coatings on the quartz grains. This rules out transport of the sand by saltation but is consistent with transport of the mud and sand in suspension. The mud's most likely source is the offshore deposits found at depths of 60 - 120m.

Above an erosional break is a medium orange sand containing abundant pebbles, occasional cobbles and boulders and small amounts of very fine sand. The lack of age structure in the deposit and the mixed lithology and variable roundness of the clasts demonstrate that this is not a slope wash deposit. Also, it was emplaced sufficiently rapidly to shift the course of a creek draining onto the beach over 15m westward and raise its bed at least 6m. The sand is characterised by low carbonate content and numerous large angular clasts.

The third, most extensive, deposit is characterised by abundant shell hash, which in places has cemented into calcarenite which now forms prominent outcrops. Once again grain size analysis discounts an aeolian origin, a conclusion reinforced by the presence of a blocky mud lens containing finely ground aragonite and calcite. Cemented calcarenite can be traced from the rear of the beach to 120m above mean sea level, 750m inland, at which point it is only 10m below the watershed dividing the seaward and bayward sides of the headland. Sands associated with the calcarenite extend 2km inland and reach 170m, the highest points on the headland. Superficially they resemble a digitate set of aeolian parabolic dunes but a detailed consideration of their morphology and sedimentology demonstrate that these were not formed by aeolian reworking of lower level tsunami deposits. Features at odds with this interpretation include: the differing orientation of the parabolas; the asymmetry of the arms and their oversteepened sides; the closed basins near the apexes; the location of the highest ground and the bulk of the sand on the eastern arm; and the inadequate size of the source area to provide the volume of sand. The coarse, poorly sorted, sands are inconsistent with aeolian reworking and, furthermore, the deposit neither fines nor becomes better sorted towards its distal end. These considerations lead to the conclusion that all the sands are wave deposited. This means that the wave crossed the headland, at least at this location, and continued into Jervis Bay.

LANDFORM DEVELOPMENT IN MID PLEISTOCENE DUNE RIDGES, CODRINGTON, SOUTHWESTERN VICTORIA.

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The aeolian calcarenite limestone dune ridges at Codrington are approximately 1 km inland from the present sea and represent a former coastline. This series of dune limestone ridges has been described as the Bridgewater Group. The preservation of the dune ridges was due to rapid 'case-hardening' of the calcareous sands by calcrete development. Calcrete/caprock development began when the sand became stabilised by vegetation. Extensive karst features exist on these dunes despite their relatively young age.

These mid Pleistocene dunes extend for at least 20 to 30 km along the coast, and there is modification to the overall landscape by the Plio-Pleistocene volcanics. A relatively small area of intensive karst development has been studied in the area close to the Eumarella River. Within this area there are three distinct calcarenite dunes. Swamps are present in the interdune swales between the dunes.

Syngenetic caves and karst features are the predominant landforms superimposed over the features common in such strandline dune fields. The karst features were developed as the sands were being cemented into limestone. The Bridgewater Group calcareous dune ridges at Codrington contain an interesting series of caves and karst features and the dunes are separated by interdune swales which are presently swamp hollows. The large swamps in the interdune flats are most likely to be the remains of primary coastal lagoons and swamp features. The characteristic morphometric features of the caves and their relationships to the groundwater levels show interesting relationships especially as the time frame available for such development is limited.

FROM THE NILE BASIN TO THE FLINDERS RANGES: CATCHMENT RESPONSE TO ENVIRONMENTAL CHANGE

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The Nile rises in the equatorial uplands of Uganda and flows northwards for nearly 7 000 km to the Mediterranean Sea. It is flanked by fossil-bearing alluvial deposits which contain a generous slice of the environmental history of our globe. Owing to its gentle gradient and history of sustained sedimentation with minimal erosion, the lower White Nile in the central Sudan preserves a unique depositional record. Using evidence from landforms, soils, sediments, archaeology, and the fossil flora and fauna, it is possible to reconstruct the alluvial history of the lower White Nile during the past 12 000 years in some detail, and back to 40 000 years in broad outline. This time interval also spans the change from prehistoric hunting and gathering in the late Pleistocene to early food production based on plant and animal domestication in the Nile valley and adjacent Sahara during the Holocene.

Late Quaternary aeolian, fluviatile and lacustrine deposits in and near the lower White Nile valley reveal a strong contrast between the dry, cold and windy late Pleistocene climates characteristic of the Last Glacial Maximum (18 000+/-3 000 yr BP) and the wetter and warmer climates prevalent in those regions at intervals during the early Holocene. The stable carbon and oxygen isotopic composition of terminal Pleistocene and early Holocene freshwater gastropod shells from Ethiopia, Sudan and the south-central Sahara support the inference of higher regional groundwater levels and a stronger summer monsoon in those regions towards 11 500-11 000 yr BP and again towards 9 500 yr BP and 8 500-7 000BP. Buried shell-beds and recessional strandlines indicate a sudden and rapid regression of the vastly expanded terminal Pleistocene White Nile in Younger Dryas times (11 000-10 000 yr BP), coinciding with temporary closure of Lake Victoria in the Ugandan upper reaches of the White Nile.

Slackwater flood deposits in now dry tributary valleys of the Jubba River in western Somalia reveal a flood history very similar to the late Quaternary lake fluctuations in the now semi-arid Ethiopian Rift. Higher runoff before 35 000 BP was followed by prolonged aridity and widespread precipitation of gypsum and calcium carbonate. Flood levels were again high towards 25 000-20 000 BP. Runoff declined sharply towards 18 000 BP and remained very low until c. 12 000 BP, when rainfall and river flow increased dramatically. From 12 000 BP to 9 000 BP water was often abundant in the valley, water tables were high and springs active. The last major interval of high discharge was towards 7 000 BP, after which the regional climate became drier, but with brief wetter intervals towards 3 000 BP and again towards 2000-1600 BP. Taken together, this evidence is consistent with much reduced rainfall and a weaker summer monsoon during the Last Glacial Maximum and with an episodically stronger monsoon during the terminal Pleistocene and early Holocene. There is circumstantial evidence for a stronger summer monsoon towards 25 000-20 000 BP, but detailed stable isotope analysis will be needed to test this hypothesis.

In north-central India, the onset of widespread late Pleistocene valley aggradation in the Son and Belan valleys was associated with the colder, drier and windier climate of the Last Glacial Maximum, a much depleted vegetation cover, and a high ratio of sandy bedload to discharge. During the final stages of aggradation, the rivers deposited more mud than sand. Floodplain incision coincides with a stronger summer monsoon and a change from mainly bedload to suspension load transport, just as in the lower Blue and White Nile valleys.

The alluvial history of the Flinders Ranges is still poorly known. Paired samples dated independently by AMS radiocarbon and by optically-stimulated luminescence indicate widespread valley aggradation between 35 000 and 15 000 BP. The precise onset of floodplain incision is not yet dated, but coincides at least in part with a return to warmer, wetter conditions. The local hydrological response to aeolian dust deposition within these desert catchments may outweigh that of regional climate change, a topic neglected hitherto in Australia.

EVOLUTION OF THE DRAINAGE SYSTEM IN THE BALGARRI AREA, EASTERN GOLDFIELDS REGION, WESTERN AUSTRALIA.

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In the past two years the Airborne Electromagnetics (AEM) Mapping Program in the Co-operative Research Centre for Australian Mineral Exploration Technologies has been ground-truthing AEM by piggybacking on comprehensive company drilling in the Balgarri area, north-west of Kalgoorlie in the Eastern Goldfields region of Western Australia. Over 500 holes have been drilled to rock through up to 150 m of regolith in an area approximately 7 km by 7 km. A by-product of this process has been the construction of a comprehensive 3D model of the character and disposition of regolith materials in the sub-surface. This paper addresses one aspect of the information contained within that model, namely the evolution of the drainage net.

Initially the Balgarri area was drained by streams confined to narrow channels that formed a simple dendritic pattern. Over time the streams aggraded their beds, and flow became progressively less confined. Sheetwash or sheetflood over broad low angle depositional plains is now the dominant fluvial process. It is speculated that channel aggradation and the shift from confined to unconfined flow is associated with sea level fluctuations in the late Mesozoic and early Tertiary, in particular with marine deposition in the lower reaches of the drainage net (Eucla Basin). Although sea levels have fallen since the mid-Miocene, nick points are yet to retreat across deposits of the Eucla Basin (the Nullarbor Plain) and the base level for streams draining the Eastern Goldfields has effectively been maintained at around pre-regression levels. These streams have become choked with sediments derived from the hinterland, and the relative relief has significantly declined. Channelled flow has been replaced by sheetwash or sheetflood, and playa lakes have become established at sites of drainage impedance.

POSTER ABSTRACTS

LANDSCAPE UNIT MAPPING USING DIGITAL ELEVATION MODELS

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Landscape units are to be mapped in the Bega Region of NSW as a part of Paul Batten's honours thesis. A landscape unit is an area of similar topography, located in a specific part of a catchment, eg: coastal plain, escarpment, upland hills. Landscape units are to be mapped as they offer a first sweep, generic survey of the environmental characteristics of the earthís surface (after Aitchison and Grant, 1968). Therefore, they are informative in their own right, but can also form an important preliminary step to more in-depth studies of a landscape (eg. multi-attribute, soil-landscape and ersoion hazard mapping).

How should we map them? That sounds like a great topic to do a thesis on. The aim of the thesis is to develop a rigorous, systematic and physically meaningful procedure for mapping landscape units. Presently, the procedure involves characterising the general shape (relief) of the surface using a Digital Elevation Model, refining with surface roughness (local slope), cleaning based on a physically meaningful extent threshold (minimum area), then selecting contiguous units and making them complete, before classifying these units based on external relationships (relative position in the catchment).

DYNAMIC LANDFORM CHANGE IN THE MURRAY MOUTH ESTUARY OF AUSTRALIA

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The River Murray estuary, a RAMSAR Wetland Site, is an extremely dynamic region. The interplay of aeolian processes, river flows, tidal oscillations, wave action and variations in relative sea level due to global sea level changes and land subsidence, provides the energy for the ongoing dynamism. Human influences impact on many of these processes. The estuary is the terminus for the drainage of the Murray-Darling catchment, which covers almost 14 per cent (1.073×10^6 km^2) of the Australian continent. Terminal Lakes Alexandrina, Albert and the Coorong Lagoon are Holocene features, occupying Quaternary interdune areas forming in response to eustatic sea level rise following the Last Glacial maximum *ca* 18,000 years BP. Their location also reflects relative tectonic subsidence. Originally an estuary of 75,000 ha, characterised by mixing of brackish and fresh water, barrages have transformed the lakes into freshwater bodies with permanently raised levels and have reduced the tidal prism by 90 per cent.

Dislocation of the last interglacial shoreline demonstrates ongoing tectonic subsidence, with implications for the longevity of the barrage system. Already sporadic incursions of sea water into the lakes affects salinity levels and water quality. The barrage system is of vital importance for long-term water supply to Adelaide (1.2 million), which draws up to 85% of its water from the River Murray in summer.

Deleterious impacts of the barrages include accelerated of lakeshore erosion accompanied by increases in turbidity and salinity, accelerated sedimentation upstream of the barrages and the growth and consolidation of a flood tidal delta (Bird Island), largely related to reduction of river flows by three quarters. The island, now 1 km in diameter, with a highest point of 5 m asl, is vegetated by some seventy plant species. The growth of the island has the potential to lead to more frequent and permanent blockages of the Murray Mouth, with consequences for the ecological health of the remaining estuary.

The last interglacial shoreline parallels the modern shoreline several kilometres inland and most of the barrage system has been built on this substrate. The northern half of Hindmarsh Island formed during last interglacial times (125.000 years BP) when dominant longshore transport from the southeast, pushed the course of the River Murray westward, partly explaining the large elbow in the River Murray at Goolwa (Aboriginal for 'elbow'). The modern barrier system of Sir Richard and Younghusband Peninsula) formed from 7,000 years ago when sea level rose following glacier melt. Subsequently, the barriers have migrated landward, sporadically exposing lagoonal sediments on the ocean beaches. Differential loading of back barrier lagoonal sediments by the advancing dune barrier has resulted in their dislocation. Squeezing of these sediments, originally deposited close to present sea level, has contorted them and thrust them up to elevations of 10 metres above present sea level. During the Holocene an extensive sand flat with associated dunes formed immediately inland of the coastal barrier.

Aeolian processes are significant, with at least six generations of Late Pleistocene dune systems in the region. For example, during last glacial times, a system of parallel, west-east trending, yellow-red desert dunes developed around the lakes. Aeolian processes remain important: occasionally up to 5000 tonnes of sand blow along the shoreline. During mouth migration, dunes up to 2 m high have been formed and vegetated in 12 months, directly inland from the mouth. Elsewhere sand is blown from dune systems into the lagoons, clogging channels. The Murray Mouth has migrated over 1.6 km since the 1830s and up to 6 km over the past 3,000 years. Movements of 14 m in 12 hours have been observed. These documented changes reveal the dynamism and fragility of the Murray Estuary and highlight the need to minimise future human impacts.

THE RELATIONSHIP BETWEEN SLOPE AND ASPECT IN THE CULLEN BULLEN AREA OF THE BLUE MOUNTAINS, NEW SOUTH WALES

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A 25 m DEM covering the 1:25,000 Cullen Bullen map sheet was used to analyse the relationship between slope and aspect in the Blue Mountains west of Sydney to examine previous local observations of a relationship between aspect, vegetation, fire ecology and slope development (Adamson, pers. comm and in prep.). The aspect and slope of each cell was determined and histograms of slope frequency constructed for north and south facing cells. Two definitions of aspect were investigated; where north (south) facing slopes covered the sector from 300° to 060° (120°-240°) and 315° to 045° (135° - 225°). Using both definitions, south facing slopes were found to be significantly steeper than north facing slopes. For both aspect classes the modal slope was around 3° but south facing slopes in the range ≈ 5° - 25° were much more frequent.

Preliminary GIS classification of vegetation from aerial photographs suggests that there is denser vegetation on the south-facing slopes. These observations and the slope analysis, confirm field observations of asymmetric valleys (particularly noticeable in east - west oriented valleys) with contrasting thickness, structure and species of vegetation on sheltered south-facing slopes and exposed north-facing slopes. The GIS slope analysis provides support, at a broad-scale and using non-selective sampling, of the field observations of a relationship between aspect, micro-climate, vegetation and slope development. Shading of the south-facing slopes encourages higher soil moisture and denser, more mesic vegetation. These slopes are less susceptible to burning, through a variety of feedbacks, and suffer lower erosion rates than exposed north-facing slopes. North-facing slope angles decline over time resulting in asymmetric valleys forming over time-scales that must be of the order of millions of years.

ASPECTS OF PALAEODRAINAGE IN THE NORTH LACHLAN FOLD BELT, NSW

David Gibson and Roslyn Chan

CRC LEME / AGSO

Evidence for the configuration of palaeodrainage in the north Lachlan Fold Belt (LFB) region is essential to determine landscape history of the area, and is mainly provided by alluvial deposits and valley basalts of various ages, and analysis of drainage directions and valley character. In many cases, palaeodrainage directions are oblique to present day drainage, and indicate a dynamic palaeohydrological regime, affected by continental breakup, subsidence of basins, global sea levels, and climate. The oldest alluvial sediments are Jurassic, and are outliers of the Great Australian Basin (GAB), deposited by north-flowing watercourses. We consider that the course of the Darling River is most likely tectonically determined, and that the northwest to westward courses of the other major rivers now draining to the Murray Basin most likely result from superimposition of drainage from now-removed GAB sediments. The direction of flow of this drainage is a result of uplift and tilting initiated at the close of sedimentation in the GAB prior to rifting of the eastern margin of Australia. Thus this drainage predates the initiation of the Murray Basin.

By the Eocene, the major rivers, and most of their tributaries (many flowing in strike valleys in LFB rocks exhumed from beneath the GAB cover) were well established and incising into their broad valley floors in their middle reaches in response to low base levels in the subsiding Murray Basin. These palaeo-gorges began to alluviate in response to climatic and base level changes in the late Eocene, with most deposition occurring from the late Miocene to the present day. They are economically important as sources of groundwater, and metals in `deep leads'. Cainozoic volcanism affected drainage in the east of the area from the Eocene onwards. We conclude, from apatite fission track (AFT) and vitrinite reflectance (VR) studies, and from our model of superimposition of drainage, that Mesozoic sediments originally extended far to the south of the preserved margin of the GAB and may have covered most of the southeastern Great Divide.

LANDSLIDE HAZARD ANALYSIS USING A DIGITAL ELEVATION MODEL, YANKALILLA, SOUTH AUSTRALIA.

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Recent advances in landslide hazard and risk analysis have focussed on formalising the engineering judgement used in conventional slope stability studies. One currently popular approach in hazard and risk investigations is the Quantitative Risk Assessment (QRA) of slopes. To date QRA's have principally been developed from either a qualitative geomorphological or quantitative engineering perspective depending on the requirements and scale of investigation.

This study has used a geomorphological-engineering approach for the assessment of landslide hazards in the Yankalilla - Normanville region of South Australia. Some 50 earthflows occur in Permian glacial, fluvioglacial and glacial-lacustrine sediments that were deposited within glacial valleys.

Preliminary studies suggest that the failure of slope for the Yankalilla region is primarily due to hydrological activity weakening the mostly unconsolidated Permian glacial deposits, with the subsequent development of shear along montmorillonite clay-rich layer(s). The loss of substrate strength is identified by the presence of soaks that are attributed to sequences of sand overlying less impervious clay in the glacial lacustrine units.

A Digital Elevation Model (DEM) has been constructed from the digitising of contours that have been gridded into a 3D surface mapping program, SurferÆ. The DEM has the advantage of extracting morphometric and hydrogeological parameters that provide fundamental information on landslide processes, and the geomorphological evolution of the region, as well as, providing ease of interpretation offered by 3D visualisation. General geomorphometric attributes, such as, slope shape, length, volume and gradient, combined with the pattern of surface drainage, are represented and correlated with slope detachment, in order to understand and predict the occurrence of slope failure.

LINKING CLIMATE, SLOPE HYDROLOGY AND SOIL STRENGTH

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Since widespread deforestation, largely completed by the end of the last century and the beginning of this century, the Hawke's Bay hillcountry has been heavily affected by rainfall triggered shallow landsliding. Many studies have been carried out about the link between rainstorms and landslide occurrence (Glade 1997) and about the spatial and temporal change in terrain resistance to landsliding (Preston 1996). This study was started in February this year and focuses on the link between climate, weather, soil water and related slope stability. The test site is a hillslope (ca. 500 m^2) in a subcatchment of the Lake Tutira catchment which has been the subject of other studies concerning hillslope hydrology (Merz 1997, Jensen 1998). Since the end of June this year, TDR-sondes and tensiometers have been installed on five sites at three depths to measure soil moisture contents as well as one piezometer per location to measure groundwater levels. A climate station is measuring precipitation, temperature, wind speed and direction, and solar radiation. In Hawke's Bay, the high number of days with strong wind is of great importance for evapotranspiration. Therefore, the Penman model will be used to calculate potential evapotranspiration because it incorporates wind speed and radiation. These data will serve as the core of a physically based model to simulate the distribution of soil water within the regolith. Shear tests to be carried out in the laboratory and in the field will be used to determine soil moisture related shear strengths in order to simulate soil moisture related slope stability.

A statistical climate model to establish the link between the Southern Oscillation Index, synoptic weather patterns and daily precipitation is about to be finished.

The results of these investigations will lead to a probabilistic climate – slope hydrology – slope stability model to determine the recurrence periods of rainstorms likely to produce landslides and the spatial extent of landslides triggered by rainstorms of a certain size.

References:

Glade, T. (1997): The temporal and spatial occurrence of rainstorm-triggered landslide events in New Zealand, unpublished PhD-Thesis, Department of Geography, Victoria University of Wellington.

Jensen, E.H. (1998): The Impact of Landslips on Contaminant Sources in steep pastoral hill country, Lake Tutira, North Island, New Zealand, unpublished MSc Thesis, Department of Geography, Victoria University of Wellington.

Merz, J. (1997): Hydrological Investigation of a Hillside affected by Landslides, Lake Tutira, New Zealand, Diplomarbeit der Universität Bern, Switzerland.

Preston, N.J. (1996): Spatial and temporal changes in terrain resistance to translational regolith landsliding, unpublished MSc Thesis, Department of Geography, Victoria University of Wellington.

RESERVOIR SEDIMENTATION AS A BASIS FOR SOIL EROSION ESTIMATES IN A SEMI-ARID ENVIRONMENT

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Sedimentation has occurred behind a masonry dam constructed approximately 115 years ago on a creek within the Mundi Mundi Creek catchment. This catchment is located within the western foothills of the Barrier Range, approximately 40 km north-west of Broken Hill, New South Wales. The dam was designed to divert surface water derived from the 12.5 ha catchment to an in-ground tank located alongside the wall. Since that time sediment has accumulated both behind the masonry wall and within the tank covering an area of approximately 1000 m^2.

The study aims to determine the frequency, number and volume of sedimentation events occurring during the last 115 years and to utilise this information to estimate the rate of soil erosion from the contributing catchment. The interpretation and dating of the sedimentary layers is being undertaken by stratigraphy, particle sizing, caesium-137, lead-210, mineral magnetic and heavy metal analyses. Estimations of soil erosion rates within the catchment are calculated from caesium-137 measurements and an Australian version of the Universal Soil Loss Equation.

Preliminary results show that an estimated 920 t of sediment has been deposited behind the masonry wall and within the tank. This suggests a catchment erosion rate of 0.64t ha^{-1} yr^{-1}, compared with preliminary USLE estimates of 0.42t ha^{-1} yr^{-1}. Caesium-137 analysis of two profiles reveal caesium-137 to a depth of 26 cm in the reservoir sediments, indicating that approximately one-third of total reservoir deposition has occurred since the 1950s.

These findings can be used to examine sedimentation and soil erosion in relation to landuse and rainfall variability, as well as for assessing the usefulness of caesium-137 to estimate soil erosion in a semi-arid environment.

THE FORMATION OF HOLOCENE GEOMORPHIC FEATURES IN ANDERSON INLET, VICTORIA, AUSTRALIA

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Anderson Inlet is a tidal estuary, situated on the eastern Victorian coastline approximately 100 kilometres south-east of Melbourne. The low coastal plateau and bluffs flanking the inlet are composed of Jurassic, Cretaceous and Tertiary formations, which have weathered to form a thin capping of sandy clays and gravel. Townsend Bluff and Nolan's Bluff abut the shoreline of the inlet. Between the plateau and the inlet is a low plain which varies both in height and in width from place to place.

The most prominent geomorphic features in this area are coastal terraces and giant Holocene sand ridges. According to the cores taken and careful field examination, three coastal terraces have been identified. The highest terrace, Terrace 3 with an elevation of about 6 m higher above the present sea level, is intermittently distributed in between Townsend Bluff and Nolan Bluff. It belongs to an erosion terrace cut possibly by sea waves through the Tertiary clay during the last interglacial. So far, there is no younger marine sediment found on this terrace. Terrace 2 can be only observed in a small area immediately east of Townsend Bluff. It is a depositional terrace mainly composed of coarse sand and overlying on the Tertiary clay. Topographic surveying indicates that whose top surface is about 2 m higher than the modern sea level. Terrace 1 with about 1.5 m in elevation is widely distributed around the Anderson Inlet and beside the Tarwin River as well. It is also a depositional terrace, sitting on the former Holocene sediments.

Two higher Holocene sea levels occurred in the research area during the Holocene. The first higher sea level started about 6650 a B.P. and ended about 6000 a B.P. At that time the sea level reached at least 1.8 m above the present one. The second higher sea level occurred from about 5500 a B.P. with the sea level reaching at least 0.5 m higher than the modern one during its maximum. Microfossil analysis and radiocarbon dating indicate that both Terrace 2 and Terrace 1 were largely related to the Holocene sea level changes. The former was attributed to the higher sea level stage(6650-6000 yr BP) when the sea reached about 1.8 m above the present sea level and the subsequent falling of the sea between 6000-5500 yr BP, the latter was formed during the higher sea level between about 5500-4000 yr BP and the recent falling of the sea.

Big sand ridges have formed a barrier system(spit) which stretches out from southeast and separates the Anderson Inlet from the open ocean. The heights of the sand ridges range generally from 30 m to 40 m above the sea level. The spit is now largely covered by dense scrub vegetation, only in some places the regular dune pattern has been interrupted by blow outs seemingly caused by southwest wind. It is so big that it is hard to believe it being a Holocene feature. However, sea level study and related palaeoenvironmental analysis show that it is really a relative young feature. It seemingly began to take form at 6000 yr BP since when the sea level dropped. An older dune has been found along the southern margin of Terrace 2, whose formation was largely related to the first higher sea level stage. The existence of such ancient dune appears to signal the difference of dominant wind regime at that time from that of today.

FERRUGINOUS CONCRETIONS FROM WILPENA POUND, FLINDERS RANGES, SOUTH AUSTRALIA.

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Ferruginous concretions up to 25 cm in diameter form part of a lag preserved at the modern land surface, south of Cooinda Camp, Wilpena Pound, South Australia. The core material of the concretions resembles clay-rich sandstone of the Cambrian Parachilna Formation. Concentrically laminated iron-oxide-rich material up to 8 cm thick encloses each core. This iron-rich material is dominantly goethitic with hematite becoming more enriched adjacent to the core. Petrographic studies indicate that the proportions of clastic quartz within the core and within the ferruginised zone are equivalent, implying that the nodules are formed wholly from the same parent lithology. Secondary goethite and hematite replace pre-existing layer silicate minerals in the matrix and infill voids. Preservation of etched feldspar clasts indicates that the sandstone was not intensely weathered at the time of ferruginisation. Therefore, the process of nodule formation is unlikely to be related to the formation of a kaolinised "lateritic" profile.

Crusts enriched in iron oxides and oxyhydroxides are presently preserved along joint planes in the stratiform sediments forming the Flinders Ranges, including Wilpena Pound. This suggests that contemporary groundwater is enriched with respect to iron as a result of weathering of the enclosing strata. The proposed mechanism for concretion formation within Wilpena Pound, a natural structural depression, follows:

(i) Partially weathered clay-rich Parachilna sandstone was episodically infiltrated by iron-bearing ground waters as a result of perched water table fluctuation within the Wilpena Pound depression.

(ii) Weathering proceeded with hematitic mega-mottle formation in the zone of water table fluctuation.

(iii) Erosion removed unconsolidated weathered material and slowly excavated the iron-mottled zone.

(iv) Nearer the surface the mega-mottles became increasingly goethitic, following the transformation of initial hematite under contemporary weathering conditions.

(v) Progressive and selective removal of alumino-silicate minerals from the mottles during ferruginisation has lead to a net concentration of iron.

(vi) Induration of mottled material once reaching the land surface has resulted in mega-nodule formation.

Optical, geochemical and mineralogical analysis of alternations within the ferruginised zone allows a detailed interpretation of concretion formation history to be constructed.

PLANATION SURFACES OF THE MOUNT LOFTY RANGES: AGE AND GENESIS

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Planation surfaces are the most prominent geomorphological features of the Mount Lofty Ranges. Two dominant surfaces pre-Middle Eocene and pre-Pliocene were distinguished amongst others within the Mount Lofty Ranges. Both surfaces are connected with long periods of planation.

The older one forms the summit surface of the Mount Lofty Ranges and is associated with a widespread epiplatform peneplain. For over one hundred million years the peneplain apparently occupied this region as well as the flanking St Vincent and the western Murray Basins. This smoothly undulating peneplain remained in a remarkably stable tectonic condition (platform or at least quasi-platform) until the Middle Eocene when sedimentation began in the flanking basins. Using the Tertiary eustatic sea-level curve the average altitude of the peneplain surface at this time was at least 200 m higher than present sea-level. The shape of this surface has been significantly changed by neotectonic movements and river erosion since the establishment of the Mount Lofty Ranges as a tectonic and geologic entity. Remnants of this pre-Middle Eocene surface and bornhardts are presently situated on and around the watersheds.

The younger planation surface is pre-Pliocene, with a hiatus of about 8-10 Ma, and is sub-horizontally covered by the Pliocene Hallett Cove Sandstone. The surface cuts across various rocks from pre-Tertiary basement to Middle Miocene and is associated with an angular unconformity. This pre-Pliocene planation surface formed along the coastal zone and included the intramontane Meadows, Myponga and Hindmarsh Tiers sedimentary basins. As sea-level change was in order of 150 m, with a long term regression, it actively affected the formation of this surface The existence of the intramontane sedimentary basins as well as marginal Barossa, Noarlunga and Willunga embayments suggests that depositional surfaces are also present within the Mount Lofty Ranges. The variety of sedimentary environments such as alluvial plain, fluviolacustrine, swamp and shallow marine, determined the varied nature of these surfaces. Abrasion planation surfaces are common in the southwestern Mount Lofty Ranges and Fleurieu Peninsula. Some of them are buried beneath the Pliocene (Hallett Cove Sandstone) and Pleistocene sediments and others developed on the pre-Tertiary basement. The origin of the diachronic planation surfaces in the Mount Lofty Ranges is therefore definitely polygenetic and include: denudation, erosion and abrasion as well as deposition.